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Contents

ON THE COVER: Mrs. Barbara Williams, Research Associate in the Department of Horticulture at The Ohio State University (left), displays drought injured plants during the Turf and Landscape Horticulture Field Day held on the Ohio State campus September 8, 1988. Although there has been ample rain since mid-July in most of Ohio, many trees and shrubs were damaged extensively and may continue to decline during the next two years.

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TOLERANCE OF NARCISSUS CULTIVARS TO SELECTED PRE-EMERGENCE HERBICIDES

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Abstract

The primary objective of this experiment was to determine if the pre-emergence herbicides Devrinol, Surflan and Endurance, applied after planting in autumn, would cause injury to four narcissus cultivars. Results suggest that all herbicides at the rates evaluated [Devrinol—5.0 lbs. aia, Surflan 3.0 lbs. aia, Endurance—2.0 lbs. aia] are safe to use with *Narcissus* 'February Gold,' 'Golden Perfection,' 'Barrett Browning' and 'Geranium.' Weed control, from an October 19, 1987 treatment, was rated very satisfactory on June 16, 1988, for both Devrinol and Surflan while Endurance was not effective.

Introduction

With only a limited number of pre-emergence herbicides registered for use on narcissus in the landscape (3), a need exists to expand the label of existing compounds or to determine if new compounds would be non-injurious. Research is also needed to evaluate the herbicides on a wider spectrum of cultivars than in past research (1).

Research in 1984 had shown Devrinol, Surflan and Treflan to be non-injurious to narcissus (2). Since that date, Devrinol has been labelled for use with narcissus along with Betasan and Chloro IPC. Among those three pre-emergence herbicides, Devrinol is the only one which is widely available to the landscape maintenance industry.

The specific objectives of this study were to compare Devrinol with Surflan, commonly used in the trade on woody and herbaceous plants, and a new herbicide, Endurance, for phytotoxicity and weed control on four cultivars of narcissus.

Materials and Methods

Narcissus cultivars selected for this evaluation included: 'February Gold' [Division 6 with yellow petals and yellow cup], 'Golden Perfection' [Division 7 with yellow petals and yellow cup], 'Barrett Browning' [Division 3 with white petals and white, red, red cup] and 'Geranium' [Division 8 with white petals and orange cup].

By selecting cultivars that had different characteristics, it was believed that more knowledge might be gained if there were cultivar differences in tolerance to the herbicides. All bulbs were planted October 12, 1987 at a depth of 6 inches.

Herbicides included: napropamide (Devrinol), oryzalin (Surflan), and prodiamine (Endurance), a new material not yet on the market. Formulations and rates were Devrinol 50 WP—5.0 lbs. aia, Surflan 75 WP—3.0 lbs. aia, Endurance 2 G—2.0 lbs. aia, and a control (no herbicide) treatment. The herbicides were applied to the soil on October 19, 1987, seven days following planting. The beds were mulched with 1 1/2-2" of utility wood chips in early November.

Each treatment was in an area 6' wide and 5' long, with a minimum of 10 bulbs per cultivar in each treatment. Plots were arranged in a randomized block design.

All evaluations for phytotoxicity were on a 1 to 10 visual scale, with 1= plant death, 10=no crop injury and 7 or above being acceptable. Weed control was rated on a 1 to 10 scale with 1=no weed control, 10=excellent weed control and 7 or above acceptable.

Phytotoxicity evaluations were conducted in April, when the plants were in bloom. Weed control was evaluated in May and June, because there were no weeds in the planting bed until then.

Results and Discussion

In this study, neither flowers nor foliage of Narcissus cultivars 'February Gold,' 'Golden Perfection,' 'Barrett Browning' and 'Geranium' were injured by the pre-emergence herbicides Endurance (2.0 lbs. aia), Devrinol (5.0 lbs. aia) and Surflan (3.0 lbs. aia) (Table 1). Devrinol was previously

Table 1. Tolerance of Narcissus cultivars to pre-emergence herbicides. Applied October 19, 1987. Evaluations April 8, 16, and 25, 1988.

		Phytotoxicity[1]											
Treatment	Rate	'February Gold'			'Golden Perfection'			'Barrett Browning'			'Geranium'		
	Lbs. aia	4/8	4/16	4/25	4/8	4/16	4/25	4/8	4/16	4/25	4/8	416	4/25
Control	—	10	10	10	—	10	10	10	10	10	—	10	10
Endurance 2 G	2.0	10	10	10	—	10	10	10	10	10	—	9.8	10
Devrinol 50 WP	5.0	10	10	10	—	9.0	10	10	10	10	—	10	10
Surflan 75 WP	3.0	10	10	10	—	9.3	10	10	10	10	—	10	10

[1]Visual Scale of 1-10 with 1=plant death, 7=acceptable injury, 10=no plant injuy

labeled for use with narcissus and within the year the Surflan label was expanded to include narcissus. Endurance is a new herbicide not yet labeled for landscape crops, but may be safe to use on narcissus based on results of this study.

The narcissus planting was mulched in November with utility wood chips and weed growth was suppressed through the April flowering period. Weeds began to become a problem in May, and by mid-June the control plants were heavily infested (Table 2). Weed control from Endurance was still acceptable in May, but superior weed control was noted with Devrinol and Surflan.

In summary, both Devrinol at 5.0 lbs. aia and Surflan at 3.0 lbs. aia can now be recommended for use on narcissus with some degree of confidence that weed control will be acceptable and phytotoxicity will be minimum.

Table 2. Spring weed control in Narcissus from autumn applied pre-emergence herbicides. Herbicides applied October 19, 1987.

	Rate	Weed Control[1]	
Treatment	Lbs. aia	May 20, 1988	June 16, 1988
Control	—	7.8	5.5
Endurance 2 G	2.0	9.0	7.3
Devrinol 50 W	5.0	9.3	8.3
Surflan 75 WP	3.0	9.3	8.3

[1]Visual Scale of 1-10 with 1=no weed control, 7=acceptable weed control and 10=perfect weed control.

Literature Cited

1. Smith, Elton M. and Sharon A. Treaster. 1982. An evaluation of pre-emergence herbicides on tulip and narcissus. Ohio Agr. Res. and Dev. Ctr. Res. Circ. 268, Ornamental Plants—1982: A Sum. of Res. pp. 20-21.
2. Smith, Elton M. and Sharon A. Treaster. 1984. Tolerance of Tulip, Daffodil, and Crocus to selected pre-emergence herbicides. Ohio Agr. Res. and Dev. Ctr. Res. Circ. 268, Ornamental Plants—1984: A Sum. of Res. pp. 14-15.
3. Smith, Elton M. and Sharon A. Treaster. 1988. Chemical Weed Control in Commercial and Nursery and Landscape Plantings. Ohio Coop. Ext. Serv. Bull. MM-297.

EFFECTS OF RONSTAR WETTABLE POWDER ON HERBACEOUS AND WOODY LANDSCAPE CROPS

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Abstract

The objective of this evaluation was to determine the efficacy and phytotoxicity of Ronstar formulations on three woody and two herbaceous species of landscape crops not already on the Ronstar label. For comparison purposes, granular (G.) and wettable (W.P.) Ronstar were evaluated with Rout and Surflan.

The results indicated that weed control was comparable between the Ronstar formulations. Phytotoxicity was usually less with the Ronstar G. treatment when compared to the W.P. From a commercial standpoint, Ronstar W.P. controls weeds as well as the G. formulation, but is more toxic to desired species. Test plots should always be established prior to large scale commercial application.

Introduction

In recent years, the use of granular Ronstar (oxadiazon) has been steadily increasing in commercial nurseries and landscape plantings. Two years ago, the wettable powder (W.P.) formulation became available to the landscape horticulture industry.

Research conducted in 1986 and 1987 at The Ohio State University has shown that new growth of some plant species of container grown plants may be injured by the W.P. formulation but not injured with the granular formulation.

To follow up this research, additional species of herbaceous and woody landscape crops were included in studies in 1988. The objective was to compare the wettable powder Ronstar with the granular formulation and other pre-emergence herbicides on unlabelled species of landscape plants.

Materials and Methods

The herbicide treatments included: Ronstar 2G. at 3.0 lbs. aia, Ronstar 50 W.P. at 2.0, 3.0, and 4.0 lbs. aia, Surflan (oryzalin) 75 W. at 1.0 lb. aia, Rout (oxyfluorfen and oryzalin) 2G. at 2.0 lbs. aia and one untreated control. All herbicide treatments were irrigated with ⅓ inch of water on the day of application.

The woody plant materials evaluated included: *Weigela florida* 'Bristol Ruby' — Bristol Ruby weigela, *Spirea* x *bumalda* 'Gold Flame' — gold flame spirea, and *Campsis radicans* — common trumpetcreeper. The herbacious plants included: *Hemerocallis* 'Magnificence' — magnificence daylily and *Hosta undulata* — wavy leaved plantain-lily.

The herbaceous plants were potted in one-gallon containers April 6 and treated with herbicides April 8, 1988. The woody species were potted in two-gallon containers April 18, and treated April 22, 1988. The media consisted of pine-bark — spaghum peat — sand (6:3:1 by volume).

Each treatment was replicated three times with three plants per treatment arranged in a randomized complete block design.

A visual scale of 1-10 was used for weed control with 1=no weed control, 7=acceptable weed control and 10=perfect weed control. Phytotoxicity was recorded with a similar scale with 1=death of plants, 7=acceptable commercial injury and 10=no injury. Evaluations were conducted eight times between treatment in April and the first week in August.

Results and Discussion

Daylily has been shown to be tolerant to Surflan (3) and in this study it was also completely tolerant to this herbicide (Table 1). However, all other herbicides caused unacceptable injury to daylily within the first week of the growing season. The plants did not die and eventually recovered, but the herbicides would not be considered safe compounds at the rates tested.

Unacceptable injury to Hosta was noted only in the Rout treatment (Table 1). The granular Ronstar and the 2.0 lb. aia wettable powder resulted in less injury to daylily than the 3.0 and 4.0 wettable powder rates.

All three woody species were tolerant to Surflan and Ronstar G. and susceptible to Rout, and all three rates of Ronstar wettable powder (Table 2). In each case, unacceptable injury was observed within the first two weeks followed by a steady progress of recovery from then until the last evaluation on August 4.

Rout was the most effective treatment in preventing weeds (Tables 1 and 2). Weed control ratings between formulations of Ronstar were essentially similar.

Table 1. Weed control and phytotoxicity of daylily and hosta to Ronstar formulations.

Herbicide, Rate, Date	Weed Control	Phytotoxicity	
		Daylily	Hosta
Check			
4-15	—	10.0[x]	10.0[y]
4-22	—	10.0	10.0
5-6	—	10.0	10.0
5-20	9.3	10.0	10.0
6-3	8.7	10.0	10.0
6-17	7.7	10.0	10.0
7-1	7.0	10.0	10.0
8-4	6.3	10.0	10.0
Rout 2G. 2.0 aia			
4-15	—	4.0	9.3
4-22	—	5.3	6.3
5-6	—	6.3	7.0
5-20	10.0	6.3	6.7
6-3	10.0	8.7	9.3
6-17	9.7	8.7	9.3
7-1	9.0	9.3	10.0
8-4	9.3	9.7	10.0
Surflan 75W. 1.0 aia			
4-15	—	10.0	10.0
4-22	—	10.0	10.0
5-6	—	10.0	10.0
5-20	9.3	10.0	10.0
6-3	9.0	10.0	10.0
6-17	8.0	10.0	10.0
7-1	7.3	10.0	10.0
8-4	6.0	10.0	10.0
Ronstar G. 3.0 aia			
4-15	—	5.0	10.0
4-22	—	6.7	9.3
5-6	—	7.0	9.3
5-20	9.3	7.0	9.3
6-3	8.3	9.0	9.3
6-17	6.3	9.0	9.3
7-1	5.7	9.0	9.7
8-4	5.3	9.7	10.0
Ronstar W.P. 2.0			
4-15	—	4.7	9.3
4-22	—	6.0	9.0
5-6	—	6.0	9.0
5-20	10.0	6.0	9.0
6-3	10.0	9.0	10.0
6-17	9.7	9.0	10.0
7-1	9.7	9.3	10.0
8-4	9.0	10.0	10.0

(Continued)

[x]All evaluations represent 3 replications of 3 plants/treatment.
[y]Visual scale with 10=best, 7=acceptable, and 1=unacceptable.

Table 1. (Continued)

Herbicide, Rate, Date	Weed Control	Phytotoxicity	
		Daylily	Hosta
Ronstar W.P. 3.0 aia			
4-15	—	4.7	8.3
4-22	—	6.3	7.3
5-6	—	7.3	7.3
5-20	10.0	6.3	7.3
6-3	9.7	9.0	9.7
6-17	8.7	9.0	9.7
7-1	7.7	9.3	10.0
8-4	6.3	10.0	10.0
Ronstar W.P. 4.0 aia			
4-15	—	4.3	8.0
4-22	—	6.0	7.3
5-6	—	7.0	7.7
5-20	10.0	6.0	7.7
6-3	10.0	8.7	9.0
6-17	9.3	8.7	9.0
7-1	8.3	8.7	9.3
8-4	7.3	10.0	10.0

Table 2. Weed control and phytotoxicity of three woody species to Ronstar formulations.

Herbicide, Rate, Date	Weed Control	Phytotoxicity		
		Weigela	Trumpet Vine	Spirea
Check				
4-29	—	10.0[x]	10.0[y]	10.0
5-6	—	10.0	10.0	10.0
5-20	9.7	10.0	10.0	10.0
6-3	8.7	10.0	10.0	10.0
6-17	7.7	10.0	10.0	10.0
7-1	6.3	10.0	10.0	10.0
8-4	5.0	10.0	10.0	10.0
Rout 2G 2.0 aia				
4-29	—	6.7	6.3	7.0
5-6	—	8.0	8.0	9.0
5-20	10.0	9.0	9.0	5.0
6-3	10.0	10.0	9.3	7.0
6-17	10.0	10.0	9.3	7.0
7-1	10.0	10.0	9.7	9.0
8-4	10.0	10.0	10.0	8.7

(Continued)

[x]All evaluations represent 3 replications of 3 plants/treatment.
[y]Visual scale with 10=best, 7=acceptable, and 1=unacceptable.

Table 2. (Continued)

Herbicides, Rate, Date	Weed Control	Phytotoxocity		
		Weigela	Trumpet Vine	Spirea
Surflan 75W. 1.0 aia				
4-29	—	10.0	10.0	10.0
5-6	—	10.0	10.0	9.7
5-20	10.0	10.0	10.0	10.0
6-3	10.0	10.0	10.0	10.0
6-17	10.0	10.0	10.0	10.0
7-1	9.7	10.0	10.0	10.0
8-4	8.7	10.0	10.0	10.0
Ronstar G. 3.0 aia				
4-29	—	9.3	9.7	8.0
5-6	—	9.0	9.7	9.3
5-20	10.0	10.0	10.0	10.0
6-3	10.0	10.0	10.0	10.0
6-17	10.0	10.0	10.0	10.0
7-1	9.0	10.0	10.0	10.0
8-4	8.0	10.0	10.0	10.0
Ronstar W.P. 2.0 aia				
4-29	—	6.7	5.0	5.3
5-6	—	7.7	5.0	4.7
5-20	10.0	9.0	6.7	4.7
6-3	10.0	10.0	8.7	5.7
6-17	10.0	10.0	9.0	6.7
7-1	9.0	10.0	9.7	8.7
8-4	7.7	10.0	10.0	9.7
Ronstar W.P. 3.0 aia				
4-29	—	6.3	4.0	4.0
5-6	—	6.3	4.0	4.3
5-20	10.0	7.3	6.0	4.7
6-3	10.0	7.3	6.3	5.7
6-17	10.0	8.3	8.7	6.7
7-1	8.7	9.3	9.3	8.7
8-4	7.3	9.3	9.7	9.7
Ronstar W.P. 4.0 aia				
4-29	—	6.3	5.0	4.0
5-6	—	6.0	4.3	4.3
5-20	10.0	7.7	6.3	3.3
6-3	10.0	9.0	8.3	4.0
6-17	10.0	10.0	8.6	6.3
7-1	9.3	10.0	9.3	8.7
8-4	8.7	10.0	9.7	9.0

Literature Cited

1. Smith, Elton M. and Sharon A. Treaster. 1986. An evaluation of oxadiazon wettable powder and granular formulations on woody landscape plants. Res. Rept. No Cent. Weed Control Conference. 43:5.
2. Smith, Elton M. and Sharon A. Treaster. 1987. Evaluation of Ronstar wettable powder on woody landscape crops. Ornamental Plants—1988: A Sum. of Res. Spec. Circular 115. The Ohio State Univ. pp. 6-7
3. Smith, Elton M. and Sharon A. Treaster. 1987. Tolerance of Daylily and Peony to Surflan, Devrinol and Treflan. Ornamental Plants—1988: A Sum. of Res. Spec. Circ. 115. The Ohio State Univ. pp. 3.

SUMAGIC: A GROWTH REGULATOR FOR WOODY PLANTS

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Abstract

The growth regulator with the trade name Sumagic (uniconizole), was effective in reducing vegetative growth of several woody landscape plants. At least one pruning operation was eliminated with English ivy, Snowmound spirea, Blue artic willow and Abbotswood potentilla without leaf distortion or discoloration . Growth was reduced on Minnesota Snowflake mockorange, and Manhattan euonymus. The 100 ppm rate was too high for Little Princess spirea, Hershey red azalea which were stunted and Royal Beauty cotoneaster which had leaf distortion.

Introduction

In the established landscape, it is often desirable to maintain woody plants at a given size with periodic pruning. In certain situations, if the need for pruning could be reduced with a growth regulator treatment, there could be an economic savings to the applicator. In large area landscapes such as cemeteries like Spring Grove, with vast areas covered with ground covers such as English Ivy and trees and shrubs considerable annual pruning is required.

Growth regulators have been available to the horticulture industry for many years; however, they have been most useful in floriculture and fruit production. In the nursery and landscape industries, several growth regulating compounds have received registration in recent years. Commercially they are used infrequently, due to the fact that they are species and timing specific. Most products have been effective on only a few species such as azaleas or rhododendrons to reduce vegetative growth (3). With the exception of maleic hydrazide (5) and Maintain CF125(1), none have been found to have widespread application.

In 1988, Sumagic became available as a foliar spray or soil drench for woody ornamentals. The primary effect is reduction of internode elongation, which results in more compact plants. One application at recommended rates normally provides season long control.

The objective of this evaluation was to determine the effect of Sumagic on the vegetative growth of selected woody ornamental plants produced in containers and established plants established in the landscape. The purpose was to reduce the amount of manual pruning required to keep fast growing species from becoming overgrown.

Materials and Methods

The first phase of this study was to treat established plants in the landscape with the intent of reducing labor for pruning. The study was conducted on the grounds of Spring Grove Cemetery and Arboretum in Cincinnati. Plants included in the study were *Hedera helix*—English ivy, *Philadelphus* 'Minnesota Snowflake' — Minnesota Snowflake mockorange and *Euonymus* 'Manhattan' — Manhattan euonymus. Prior to treatment, the mockorange and euonymus were pruned. The English ivy was not pruned, because there had been no significant prior new growth.

Sumagic (uniconizole) (2) was applied at 100 and 200 ppm as a foliar spray to run-off on June 7, 1988. The sprayer used was a 3-gallon capacity, pump type, operated at 35 psi.

In the second study, plants in one-gallon containers were treated in The Ohio State University container research nursery. Plants included *spiraea japonica* 'Little Princess' — Little Princess spirea, *spiraea nipponica* 'Snowmound' — Snowmound spirea, *Euonymus radicans* 'Erecta' — Erect euonymus, *Salix purpurea* 'Nana' — Blue artic willow, *Cotoneaster dammeri* 'Royal Beauty'— Royal Beauty cotoneaster, *Rhododendron* 'Hershey Red' — Hershey Red azalea and *Potentilla fruticosa* 'Abbotswood' — Abbotswood potentilla.

Plants were sprayed to runoff with Sumagic at 100 ppm on June 21 and evaluated August 31, 1988. Three plants of each species were treated with each treatment rate in a random design.

Results and Discussion

Sumagic at both 100 and 200 ppm spray was effective in controlling height growth of three relatively fast growing species, English ivy, mockorange and euonymus. Growth of English ivy was reduced by 43 percent at 100 ppm Sumagic and 69 percent from 200 ppm. Growth of Minnesota Snowflake mockorange was reduced by 62 percent at both concentrations of Sumagic. Manhattan euonymus growth was reduced by 12 and 24 percent, respectively, at 100 and 200 ppm (Table 1).

In all cases, the visual effect of the growth regulator had become less and less effective as the summer season came to a close. Generally, it is desirable for the plants to resume normal growth by the end of the season without a carryover effect.

In the research nursery it was apparent that the reduction to Sumagic was, in some cases, equal to that in the landscape as shown in Table 2.

It should be noted that the objective may not be to inhibit growth completely, but rather to reduce growth so that at least one pruning operation could be eliminated. The Little Princess spirea and Hershey Red azalea were too stunted at the 100 ppm rate. However, 100 ppm seemed to be an excellent rate for Snowmound spirea, Blue artic willow and Abbotswood potentilla when applied June 21, 1988.

At least one pruning was essentially omitted with the English ivy in the landscape and the Snowmound spirea, Blue artic willow and Abbotswood potentilla in the nursery.

More research is definitely needed with additional species at more rates. However, for perhaps the first time, we have a compound that appears to have effectiveness on a fairly broad range of woody landscape plants.

Table 1. Effects of Sumagic on shoot elongation of established woody landscape plants in the landscape. Plants treated June 7, 1988 and evaluated August 31, 1988.

		Landscape Plants					
		English Ivy		Mockorange		Euonymus	
Treatment	Rate	Growth Inches	Percent Reduction	Growth Inches	Percent Reduction	Growth Inches	Percent Reduction
Control	0 ppm	10.8	0	6.3	0	10.9	0
Sumagic	100ppm	6.2	43	2.4	62	9.6	12
Sumagic	200 ppm	3.3	69	2.4	62	8.3	24

Table 2. Effects of Sumagic on the shoot elongation of woody plants grown in containers. Plants treated June 21, 1988 and evaluated August 31, 1988.

Landscape Plant	Control	Sumagic 100 ppm	Percent Reduction
Little Princess Spirea	19.0"	9.3"	51.1
Snowmound Spirea	23.3	10.7	54.1
Erect Euonymus	13.7	11.0	19.8
Blue Artic Willow	23.0	19.7	14.4
Royal Beauty Cotoneaster	19.7	17.0	13.8
Hershey Red Azalea	13.3	5.3	60.2
Abbotswood Potentilla	19.0	14.0	26.4

All figures represent the means of 9 plants.

Literature Cited

1. Anonymous. 1985. Maintain CF125, Product Use Guide. Leffingwell, Brea, CA.
2. Anonymous. 1986. Sumagic Technical Information Bulletin. Chevron Chemical Co., San Francisco, CA.
3. Furuta, Tokuji. 1967. Chemical pinching agents for azaleas. Univ. of Cal. Agr. Extension Service AXT-256.
4. Sach, R.M., W.P. Hackett, R.G. Maire, T.M. Kretchun and J. de Ble. 1970. Chemical control of plant growth in landscapes. Cal. Agr. Exp. Sta. Bul. 844.

EVALUATION OF FLOWERING CRABAPPLE SUSCEPTIBILITY TO APPLE SCAB IN OHIO—1988

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Abstract

In a 1988 survey of Ohio arboretums and nurseries, there were 128 selections of flowering crabapples (Malus species and cultivars) found to be resistant or highly resistant to apple scab. There were 82 selections susceptible or highly susceptible. Weather conditions in 1988 were relatively dry in all areas from April through mid-July, accounting for the relatively low incidence of diseased plants.

Introduction

Apple scab caused by *Venturia inequalis* is a fungus disease which infects *Malus* species and cultivars. The disease is first manifested by olive gray spots on the foliage followed by yellowing and defoliation of susceptible selections of flowering crabapple. Continued defoliation will weaken trees, reduce bloom in succeeding years and contribute towards greater winter injury.

Apple scab can be reduced or eliminated by planting resistant selections. The disease can be controlled by spraying but this is a continual process requiring application every two weeks from late April until autumn.

The objective of this study was to evaluate flowering crabapples in nurseries and arboretums in Ohio for tolerance to apple scab. A statewide evaluation is valuable because it allows growers, retailers and landscapers to know which selections have proven to be resistant and which are too susceptible to this most significant disease of flowering crabapple in Ohio.

Materials and Methods

In August 1988, a survey of flowering crabapples was conducted in Ohio arboretums and nurseries. Apple scab severity was rated and the presence of other diseases such as fireblight, cedar apple rust and frog eye leaf spot were also noted. Since the severity of the latter three diseases are usually not serious enough in Ohio to discontinue planting, ratings were not given.

The infestation of apple scab was rated as follows: HR=highly resistant—no indication of disease; R=resistant—mild infection with no defoliation; S=susceptible—medium infection with only slight defoliation; and HS=highly susceptible—heavy infection often accompanied by considerable defoliation.

More than one rating may appear in the table for a given selection as severity of infection varied among locations. The variation was most likely due to differences in time and amount of rainfall as well as average relative humidity.

Results and Discussion

Some degree of variability in apple scab exists from year to year based on previous observations by the authors (2, 3, 4, 5). Rainfall between April and mid-July was almost non-existent with only sporadic showers.

In the 1988 survey there were 128 selections rated highly resistant or resistant while 82 were susceptible or highly susceptible. Comparing similar seasons there were 127 selections resistant and 79 susceptible in 1985 (4). In 1984, the most recent prolonged wet spring and summer, there were 89 selections resistant and 114 susceptible (3).

In 1988, among the most disease resistant selections to apple scab, fireblight, cedar apple rust and frog eye leaf spot were: *Malus* 'Adams', 'Beverly', 'Bob White', 'Centennial', 'Christmas Holly', 'Coralburst', 'David', 'Dolgo', 'Donald Wyman', *floribunda,* 'Golden Hornet', 'Golden Gem', 'Klehm's Improved', 'Jewelberry', 'Liset', 'Makamik', 'Mary Potter', *micromalus,* 'Milton Barron', 'Molton Lava', 'Ormiston Roy', 'Prairifire', 'Prince Georges', 'Prof Springer', *prunifolia* 'Fastigiata', *prunifolia* ' Pendula', 'Red Jade', 'Red Jewel', *robusta* selections, *sargenti,* 'Selkirk', 'Sentinel', 'Silver Moon', 'Strawberry Parfait', 'Sugartyme', tschonoksi, 'White Angel', 'White Cascade', *yunnanensis* selections and *zumi* 'Calocarpa.'

Flowering crabapples rated highly susceptible to apple scab in 1988 were: 'Almey', 'Amisk', *arnoldiana,* 'Arrow', 'Barbara Ann', 'Dorothea', 'Evelyn', 'Hopa', 'Katherine', 'Pink Flame', 'Pink Spires', 'Pink Weeper', 'Purple Wave', 'Eleyi', 'Radiant', 'Red Silver', 'Tanner', and 'Vanguard'. Due to the severity of apple scab this and in previous years (2, 3, 4, 5) these should be discontinued from planting in Ohio.

To obtain information relative to cultural requirements and descriptions of recommended flowering crabapples consult the publication titled, "The Flowering Crabapple—A Tree For All Seasons" (1) available from county Extension Service offices. Additional information can be obtained by visiting one of several arboretums in Ohio in late April—early May. Outstanding collections of flowering crabapples can be located in the Dawes Arboretum in Newark, Holden Arboretum in Kirkland Hills, and the Secrest Arboretum in Wooster.

TABLE 1. Susceptibility of Flowering Crabapples to Apple Scab—1988 Apple Scab Rating.

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Adams'	x				
M. x adstringens				x	
'Almey'				x	
'Amberina'			x		
'Amisk'				x	
'Amur'			x		
'Anne E'	x	x			
'Arnold Arboretum'				x	
M. x arnoldiana				x	
'Arrow'				x	
M. atrosanguinea				x	
M. baccata			x		Fireblight
M. baccata 'Ceratocarpa'			x		
M. baccata columnaris	x				Frog Eye Leaf Spot
M. baccata 'Jacki'	x				Fireblight
M. baccata 'Mandshurica'				x	
M. baccata 'Midwest'	x				
'Barbara Ann'				x	
'Beverly'	x				
'Bob White'	x				
'Brandywine'	x				
M. brevipes				x	
'Burgundy'	x				
'Candied Apple'	x	x			
'Cashmere'	x				
'Centennial'	x				
'Centurion'	x	x			
'Cheal's Crimson'		x			
'Chestnut'	x				
'Chilko'		x			
'Christmas Holly'	x				
'Coralburst '	x	x			
M. coronaria 'Charlottae'				x	Cedar Apple Rust
M. coronaria 'Nieuwlandiana'		x	x		Cedar Apple Rust
'Cowichan'			x	x	
'Crimson Brilliant'				x	
'Dainty'	x	x			
'David'	x				
'Dawsoniana'	x				
'Dolgo'	x				
'Donald Wyman'	x				
'Dorothea'				x	
'Dorothy Rowe'	x				
'Ellen Gerhart'		x	x		
'Exzellenz Thiel'				x	
'Flame'		x	x		
'Flexilis'	x				

(Continued)

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible.

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Pink Beauty'		x			
'Pink Cascade'	x				
'Pink Dawn'		x	x		
'Pink Flame'				x	
'Pink Spires'			x		
'Pink Weeper'				x	
'Prairie Rose'	x				
'Prairiefire'	x				
'Pretty Marjorie'	x				
'Prince Georges'		x			
'Profusion'		x			
'Prof. Springer'	x				
M. prunifolia				x	
M. prunifolia 'Fastigiata'	x				
M. prunifolia 'Pendula'	x				
M. pumila 'Elise Rathke'		x	x		
M. pumila 'Niedzwetzkyana'			x		
M. pumila 'Paradise Foleus Aureus'	x				
'Purple Wave'				x	Fireblight
M. purpurea				x	
M. purpurea 'Aldenhamensis'			x		
M. purpurea 'Eleyi'				x	
M. purpurea 'Lemoinei'			x	x	
M. Pygmy	x				
'Radiant'				x	
'Ralph Shay'	x	x			
'Red Baron'		x	x		
'Red Bud'			x		
'Red Edinburgh'				x	
'Red Flesh'				x	
'Red Jade'	x				
'Red Jewel'	x				
'Red Swan'	x				
'Red Silver'			x		
'Red Splendor'		x			Frog Eye Leaf Spot
'Ringo'			x		
'Robinson'		x			
M. x robusta	x				
M. x robusta 'Erecta'	x				Frog Eye Leaf Spot
M. x robusta 'Persicifolia'	x				
'Rosseau'	x				Frog Eye Leaf Spot
'Royal Ruby'		x			
'Royalty'		x	x		
'Ruby Luster'		x			
M. sargentii	x				
M. sargentii 'Rosea'	x				
M. sargentii 'Rose Low'	x				
'Satin Cloud'	x				
M. x scheideckeri				x	
M. x scheideckeri 'Hilleri'			x	x	

(Continued)

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible.

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Scugog'		x	x		
'Selkirk'	x				
'Sentinel'	x				
'Shakespeare'				x	
M. sieboldi	x				
M. sieboldi 'Arborescens'	x				
M. sieboldi 'Fuji'	x				
M. sikkimensis	x				
'Silver Moon'	x				
'Simcoe'			x		
'Sissipuk'	x				
'Snowcap'	x				Fireblight
'Snowcloud'		x	x		
'Snowdrift'		x	x		
'Snowmagic'			x		
M. x soulardii		x			Cedar Apple Rust
'Sparkler'				x	
M. spectabilis	x				
M. spectabilis 'Albi-Plena'		x			
M. spectabilis 'Van Eseltine'	x				
'Spring Song'			x		
'Spring Snow'		x			
'Strathmore'				x	
'Strawberry Parfait'	x				
M. x sublobata		x			
'Sugartyme'	x				
'Sundog'	x				
M. sylvestris 'Plena'		x			
'Tanner'				x	
M. toringoides	x				
M. toringoides 'Macrocarpa'	x				
'Trail'	x				
M. tschonoski	x				
'Turesi'				x	
'Vanguard'				x	
'Velvet Pillar'			x		
'Wabiskaw'			x	x	
'White Angel'	x				
'White Candle'			x	x	
'White Cascade'	x				
'Wickson'	x				
'Wilson'		x			
'Winter Gold'		x	x		
'Wooster No. 1'	x				
M. yunnanensis 'Veitchi'	x				
M. yunnanensis					
'Veitch's Scarlet'	x				
M. zumi			x		
M. zumi 'Calocarpa'	x				

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible.

Literature Cited

1. Brewer, J.E., L.P. Nichols, C.C. Powell and E.M. Smith, 1979. The Flowering Crabapple—a tree for all seasons. Coop. Ext. Serv. of Northeast States. NE 223, NCR 78.
2. Smith, Elton M. 1979. A 10 year evaluation of flowering crabapple susceptibility to apple scab in Ohio. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 246. Ornamental Plants 1979: A Sum of Res. pp 36-39.
3. Smith, Elton M. 1984. Evaluation of flowering crabapple susceptibility to apple scab in Ohio—1984. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 284, Ornamental Plants—1984: A Sum. of Res. pp 19-22.
4. Smith, Elton M. and Sharon A. Treaster, 1985. Evaluation of flowering crabapple susceptibility to apple scab in Ohio 1985. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 289, Ornamental Plants 1985: A Sum. of Res. pp 4-8.
5. Smith, Elton M. and Sharon A. Treaster, 1986. Evaluation of flowering crabapple susceptibility to apple scab in Ohio 1986. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 291, Ornamental Plants—1987: A Sum. of Res. pp 3-7.

AN EVALUATION OF SNAPSHOT, A NEW PRE-EMERGENCE HERBICIDE

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Abstract

Snapshot, a new pre-emergence herbicide designed for the nursery industry, was evaluated on selected container grown woody landscape crops. Two formulations, a dispersable flowable (DF) and a granular (G) are available for experimental use. The DF is a combination of oryzalin (Surflan) and isoxaben (Gallery) and the G formulation is a combination of trifluralin (Treflan) and isoxaben (Gallery).

Weed control with Snapshot DF at 3.0 and 4.0 lbs. aia was acceptable through 11 weeks when the study terminated. Weed control with the G formulation at 3.75 lbs. aia was equally effective through 11 weeks.

There was no phytotoxicity to Hino Pink azalea, Royal Beauty cotoneaster, Emerald 'N Gold euonymus or Blue Rug juniper with either formulation or rate throughout the study.

Introduction

Currently, there are approximately 18 pre-emergence herbicides or herbicide combinations registered for use in commercial nurseries (1). Despite this relatively high number, the industry is still looking for a product that will control a wide spectrum of weeds, including annual grasses and broadleaved species without appreciable injury to a wide range of landscape plants.

Two compounds, Surflan and Treflan have a wide spectrum of landscape plants on the label. They are both quite effective in the control of annual grasses, but are relatively weak on broadleaved weeds. A new material, Gallery, with the common name of isoxaben, from Elanco Products Co., controls broadleaf weeds quite well. By combining isoxaben with Surflan or Treflan, a broader spectrum of weeds can be controlled.

The objectives of this study were to evaluate weed control and plant injury on commonly grown woody landscape crops that are labeled for both Surflan and Treflan.

Materials and Methods

Plant materials selected for this study included: *Rhododendron* 'Hino Pink'-Hino Pink azalea, *Cotoneaster dammeri* 'Royal Beauty'—Royal Beauty cotoneaster, *Euonymus fortunei* 'Emerald 'N Gold'—Emerald 'N Gold euonymus and *Juniperus horizontalis* 'Wiltoni' —Blue Rug juniper. The plants, all grown from cuttings the previous year, 4-8" in height, were potted into one-gallon containers in a pine bark-peat-sand (6-3-1 by volume) medium on May 23, 1988. All plants were fertilized with Osmocote 18-6-12 the same day and thoroughly irrigated. All plants were irrigated as needed throughout the summer.

The herbicides utilized in this study were experimental compounds containing two pre-emergence materials. Snapshot DF is a combination of oryzalin (Surflan) and isoxaben. Snapshot G is a combination of trifluralin (Treflan) and isoxaben. The herbicide treatments included Snapshot DF at 3.0 and 4.0 lbs. aia and Snapshot G at 3.75 lbs. aia. Plants were treated with herbicides on May 25, 1988.

Each treatment had three, three plant replicates arranged in a randomized complete block design. The study was conducted in The Ohio State University research container nursery.

Containers were evaluated for weed control using a visual scale of 1-10, with 1=no weed control, 7=acceptable weed control and 10=perfect weed control. Phytotoxicity of the nursery stock was evaluated in a similar fashion with 1=death of plants, 7=acceptable commercial injury and 10=no injury. Evaluations were conducted approximately every 2 weeks for 11 weeks.

Results and Discussion

Weed control during the 11 weeks of the study, was acceptable with Snapshot DF at 3.0 and 4.0 lbs. aia and Snapshot G at 3.75 lbs. aia (Table 1). Weeds controlled by the two formulations included: annual bluegrass, pigweed, purslane, spotted spurge and wild lettuce. Yellow wood sorrel or oxalis was not controlled in a satisfactory manner. It is pleasing to note that a wide spectrum of weeds was controlled for nearly three months. Most herbicides registered for the nursery industry are effective for only eight to 10 weeks, particularly in container production, where high rates of irrigation are utilized.

Plants grown from rooted cuttings the previous season are much more sensitive to injury from herbicides than plants a year or more in age. Despite the small-size plants there was no observable injury to any of the four species of plants at any time during the study (Table 1.) Hino Pink azalea is a very sensitive cultivar and no injury was observed, indicating that Snapshot DF and G at rates of 3.0 to 4.0 lbs. aia may have a good tolerance with woody landscape plants.

In very few studies, do we witness season-long weed control with no phytotoxicity to the test species. These products seem to hold an encouraging future in the nursery industry. Much more research, however, needs to be conducted with additional species at varying rates before the products can be introduced into the marketplace.

Literature Cited

1. Smith, Elton M. 1988. Chemical weed control in commercial nursery and landscape plantings. MM-297. Ohio Coop. Ext. Serv., The Ohio State University.

Table 1. Weed control and phytotoxicity of Snapshot in selected container grown nursery crops.

					Phytotoxicity[y]											
Herbicide	Rate	Weed Control[x]			Azalea			Juniper			Euonymus			Cotoneaster		
Treatment	aia	6/22	7/19	8/17	6/22	7/19	8/17	6/22	7/19	8/17	6/22	7/19	8/17	6/22	7/19	8/17
Control		9.2	6.7	4.3	10	10	10	10	10	10	10	10	10	10	10	10
Snapshot DF	3.0	10.0	9.0	7.7	10	10	10	10	10	10	10	10	10	10	10	10
Snapshot DF	4.0	10.0	10.0	8.0	10	10	10	10	10	10	10	10	10	10	10	10
Snapshot G	3.75	9.7	9.3	8.0	10	10	10	10	10	10	10	10	10	10	10	10

[x]Visual Evaluation where 1=no weed control, 7=acceptable weed control and 10=perfect weed control.
[y]Visual Evaluation where 1=complete death, 7=acceptable plant injury and 10=no plant injury.

AN INVESTIGATION OF THE CHEMICAL AND PHYSICAL PROPERTIES OF INTERIOR TROPICAL FOLIAGE PLANT GROWING MEDIA

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Abstract

The objective of this study was to conduct a survey to characterize the chemical and physical properties of growing media contained in the pots of tropical foliage plants received from production sites and intended for installation in interior plantscape sites. A total of 39 firms participated in this study submitting 150 samples for analysis.

Chemical analysis reports indicate that levels of soluble salts and various individual salts that contribute to soluble salts readings could be potential problems if not monitored and dealt with before placing into the interior environment. Analysis of physical parameters indicates that there is variation among tropical foliage plant producers regarding potting media moisture retention characteristics.

Growing media plays an important role in the successful maintenance of plants in interior landscapes. Besides affecting plant health, growing media anchors the plant and is a source of oxygen to plant roots. It also holds moisture and supplies nutrients to the plants that are essential for plant growth.

There is no single best growing medium for foliage plants. Most potting mixes are blends of two or more components formulated to combine physical and chemical properties to obtain better physical and chemical characteristics than one component alone. Characteristics of growing media that need to be considered include weight, cation exchange capacity, aeration or pore space, water holding capacity, carbon: nitrogen ratio, pH, soluble salt level, rate of decomposition and compaction. Cost, uniformity, sterility, availability, reliability of supply and ease of handling should also be taken into consideration (7).

A suitable growing medium, must not only provide sufficient amounts of water and essential elements for the plant's needs, but it must also provide an environment suitable for the growth and functioning of the root system (3).

Until recently, growing media for interior landscapes usually contained a high percentage of natural soil. Used alone, soil is seldom the best choice for indoor use because it may not provide adequate drainage or aeration. To alleviate these problems, organic components, such as sphagnum peat moss, and coarse aggregates, such as sand, vermiculite and perlite, are usually added to improve soil structure and aeration (4).

Most container research has dealt with the relation of medium characteristics to optimum production (1, 8). Little research has been done to identify the source of problems relating to chemical and physical conditions within the growing media which may contribute to the rapid or progressively slow decline of foliage plants in interior locations.

The objective of this study was to characterize the chemical and physical properties of growing media contained in the pots of tropical foliage plants received from production sites for installation in interior plantscape sites.

Materials and Methods

Interior plantscape industry firms throughout the United States were identified to serve as cooperators in this study. Cooperators were identified on a volunteer basis and asked to make a modest monetary contribution to the project. The names of cooperators remained confidential and specific results of analyses and evaluation for each cooperating firm were not revealed to anyone but the cooperator.

A sampling kit for collecting and submitting the growing media samples was developed. This kit included instructions for sampling, an information sheet about the sample, a sample container and a mailer. Each plantscape firm that participated was sent the sampling kit and asked to submit five samples for analysis.

Samples were received for analysis beginning in August 1986. Collection time ran from August 1986 until April 1987. Thirty-nine horticultural firms involved in interior plantscaping submitted 150 growing media samples for analysis. Each sample received was analyzed chemically for pH, conductivity (soluble salts), nitrate nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, copper, boron, zinc, sodium, chloride and fluoride using standard procedures (6). Samples were analyzed physically for total and air filled porespace and water holding capacity using aparatus and methods described by Leamer and Shaw (2) and White and Mastalerz (9). Bulk density and total porosity were calculated from the results of these physical tests.

Results

Physical Testing Results

This study has revealed that the physical composition of growing media used by growers supplying interior plantscapers with plant material consists largely of soilless media components (Table 1). Water holding capacity of the growing media samples tested appeared to differ over time depending on the composition of the media (Figure 1). This difference appeared to be related to the amount of soil incorporated in the growing mix.

Chemical Testing Results

Results from the chemical analysis portion of the survey were compared with optimum levels for each element derived from analysis results of samples submitted for evaluation to the R.E.A.L. lab at the Ohio Agricultural Research and Development Center in Wooster, Ohio (5). These levels are optimum for growing media used specifically in interior landscaping. This research revealed that 48.7 percent of the samples tested had pH levels higher than optimum, whereas 38 percent of the samples had pH levels that are considered low for use in interior plantings (Figure 2, Tables 2,3). In all, 86.7 percent of the samples have pH levels higher or lower than the acceptable range for plants to be used in the interior environment. Soluble salt levels were high in 56 percent of the samples tested (Figure 3, Table 4). Levels of sodium, copper and fluoride did not exhibit any trend in levels compared to recommended ones.

One observation that needs further investigation is the extreme variability in values obtained for each chemical element analyzed (Table 5). This large range in values suggests that there is no standard media composition and/or no standard fertilization programs utilized in the segment of the production industry producing plants for use in interior landscapes.

This may be the result of a lack of information regarding optimum fertility programs for tropical foliage plants to be placed in interior environments.

Discussion

Findings of this study will provide an opportunity to focus future research on identifying procedures, equipment and materials for use in the interior plantscape industry to avoid or correct potential problems indentified by this research. This research should also provide insights and information to permit the interior plantscape industry to provide cultural material or handling recommendations to tropical foliage plant producers to insure the quality and longevity of the plants in the interior environment.

Table 1. Percentages of samples tested containing individual media components.

Component	Percent (%)
Sand	98
Peat Moss	95
Bark	86
Styrofoam	51
Slow Release Fertilizer	31
Perlite	28
Vermiculite	0.08
Soil	0.05
Others	0.01

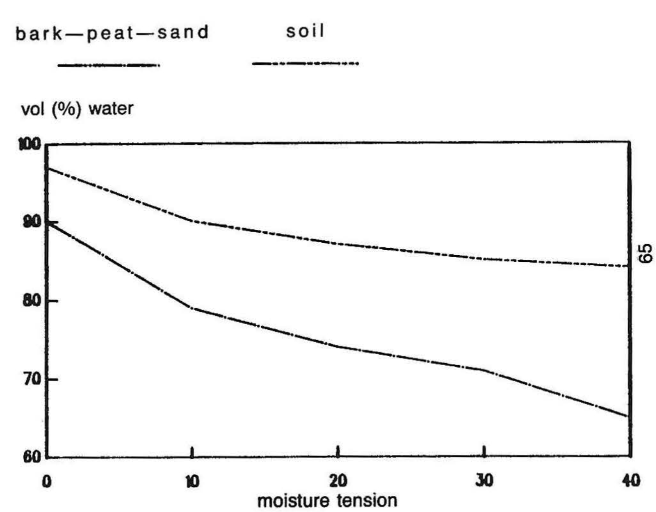

Figure 1. Average Moisture Release Curves for growing media samples tested consisting of either bark, peat moss and sand, or soil.

Table 2. Results of chemical analysis of growing media.

Parameter	Mean value	Minimum value	Maximum value
pH	5.52	3.45	7.25
Soluble Salts (mmhos)	1.81	0.10	9.00
Nitrate-N (mg/l)	216.94	1.00	1470.00
Phosphorus (mg/l)	31.42	<0.40	241.00
Potassium (mg/l)	145.69	3.07	1034.00
Calcium (mg/l)	276.37	12.59	915.10
Magnesium (mg/l)	107.81	4.95	1531.00
Sodium (mg/l)	40.28	3.59	276.00
Iron (mg/l)	1.20	0.01	60.40
Manganese (mg/l)	4.00	<0.003	75.03
Zinc (mg/l)	1.05	<0.02	12.16
Copper (mg/l)	0.13	<0.02	4.51
Boron (mg/l)	0.29	<0.01	2.66

Table 3. Evaluation of growing media pH levels for interior plants.

	Soil Mix (>20% Soil)	Soil-Less Mix (<20% Soil)
Extremely low	4.9 or less	4.5 or less
Very Low	5.0—5.4	4.6—4.7
Low	5.5—5.9	4.8—4.9
Slightly Low	6.0—6.4	5.0—5.1
Optimum	6.5—6.8	5.2—5.5
Slightly High	6.9—7.2	5.5—5.8
High	7.3—7.4	5.9—6.3
Very High	7.5—7.6	6.4—6.8
Extremely High	>7.7	>6.9

Table 4. Evaluation of growing media chemical composition for interior plants.

	500+foot candles (f.c.)	300-500 f.c.	300 f.c.
	Soluble salts (mmhos/cm)		
High	1.50+	1.25	1.00
Satisfactory	0.50-1.50	0.40-1.25	0.30-1.00
Low	Below 0.50	Below 0.40	Below 0.30
	Nitrogen (mg/l)		
High	176+	151+	101+
Satisfactory	100-175	75-150	50-100
Low	77-99	60-74	30-49
Very Low	<70	<60	<50
	Calcium (mg/l)		
High	301+	276+	276+
Satisfactory	225-300	200-275	175-275
Low	125-224	100-199	100-199
Very Low	<125	<100	<100
	Magnesium (mg/l)		
High	126+	101+	101+
Satisfactory	75-125	60-100	50-100
Low	50-75	40-59	40-49
Very Low	<50	<40	<40
	Phosphorus (mg/l)		
High	15+	11+	11+
Satisfactory	8-14	6-10	6-10
Low	6-7	4-5	4-5
Very Low	<6	<4	<4
	Potassium (mg/l)		
High	151+	126+	100+
Satisfactory	100-150	75-125	65-100
Low	75-99	60-74	50-64
Very Low	<75	<60	<50

	Optimum Ranges (mg/l)
Manganese	0.02 - 3.00
Iron	0.30 - 3.00
Boron	0.05 - 0.50
Copper	0.001- 0.05
Zinc	0.30 - 3.00
Sodium	potential problem above 50
Fluoride	potential problem above 2-3
Chloride	no information available

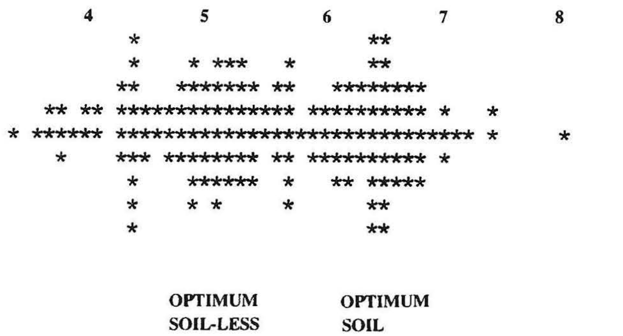

Figure 2. Frequencies of pH values in growing media samples.

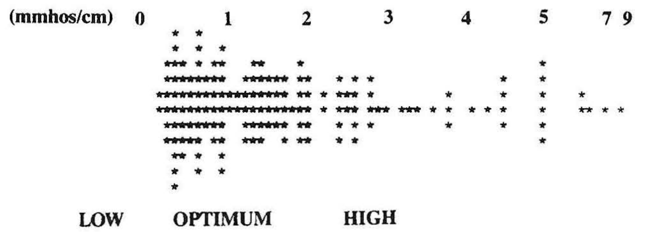

Figure 3. Frequencies of soluble salt levels in growing media samples.

Table 5. Frequencies of individual chemical element levels in growing media samples.

	Percent (%)		
Chemical component	Low	Optimum	High
Phosphorus	27	25	48
Potassium	47	21	32
Calcium	56	31	13
Magnesium	48	26	26
Sodium	76	24 (Potential Problem)	
Iron	66	28	6
Manganese	33	42	25
Zinc	36	54	10
Boron	15	70	15
Nitrate Nitrogen	31	22	47
Copper	60	—	40
Boron	15	70	15
Fluoride	78	18	4

Acknowledgement

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Bibliography

1. Fonteno, W.C., D.K. Cassel and R.A. Larson. 1981. Physical properties of three container media and their effect on poinsettia growth. Hort Sci. 106(6):736-741.
2. Leamer, R.W. and B. Shaw. 1941. A simple aparatus for measuring noncapillary porosity on an extensive scale J. Amer. Soc. Agron.
3. Manaker, G.H. 1981. Interior Landscapes. Prentice-Hall, Inc., Englewood Cliffs, N.J.
4. Manaker, G.H. 1984. Soilless media for interior land-scapes. Interior Landscape Industry 1(5): 42-47.
5. Peterson, J.C. 1984. Interior plant media analysis evaluation. Unpublished data.
6. Peterson, J.C., D. Kervin, D.K. Markus, D.D. Warncke, P.V. Nelson, W.R. Faber, R. Wright, A.C. Bunt, and T.E. Bilderback. 1986. Interpretation of extraction and nutrient determination procedures for organic potting substances. Hort Sci. 21(2): 213-232.
7. Poole, R.T. and C.A. Conover. 1980. Light weight soil mixes. Interior Plantscape Association Manual of Practice.
8. Poole, R.T. and W.E. Waters. 1972. Evaluation of various potting media for growth if foliage plants. Proc. Fla. State Hort. Soc. 85:394-398.
9. White, J.W. and J.W. Mastalerz. 1966. Soil Moisture as related to "Container capacity". Proc. Amer. Soc. Hort. Sci. 89:758-765.

DISEASE SUPPRESSIVE PROPERTIES OF CONTAINER MEDIA

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Introduction

Container media that provide natural control of diseases caused by plant pathogens have been available to florists and nurserymen for a decade now. This activity is almost entirely due to amendments with composts. Suppression of diseases in these media is due to biological, chemical, as well as physical factors. Interactions involved are very complex. Because of this, *many producers of container media have shied away from focusing in on the high level of quality control required for the preparation of composts and for formulation of predictably disease suppressive container media.*

Effective systems for control of *most* soilborne plant pathogens are available today that do not include biological control. Strategies involved include resistance, eradication or exclusion, sanitation and chemical control with fungicides. It could be argued, therefore, that biological control is not a high priority. Chemical control, however, is not achieved without significant costs and is not always feasible. *The purchase cost of fungicides for root rot control of a rhododendron crop may equal the purchase cost of a container medium.* Other valid reasons for exploring biological control are the phytotoxic response of some seedlings to specific fungicides and potential mammalian toxicity associated with the use of fungicides. One final reason for continued research into biological control with composts is the lack of control procedures for a few serious diseases. Fusarium wilts, for example, still may cause serious losses because their integrated control procedures, not including a biological control strategy, are deficient.

Any review of pros and cons associated with compost-amended container media should include aspects other than disease control. Disease control is one of many factors to be considered in production. Some composts contain balanced levels of micronutrients. Media prepared with composted municipal sludge have adequate levels and should not be amended with trace elements. This is a significant advantage. It holds the potential to eliminate frequently encountered oxicity or deficiency levels of such elements in commercial peat media. It is difficult to blend small quantities of these chemicals into media without also destroying physical roperties related to drainage. The amount of mixing, therefore, sometimes is less than adequate resulting in nutritional problems.

Role Of Organic Matter Decomposition Level In Biological Control

Fresh, undecomposed organic matter generally serves as a food base for plant pathogens. Green manures increase Pythium disease if sensitive crops are planted on the day of incorporation. Within weeks, however, this stimulatory effect on *Pythium* has disappeared. Hardwood bark and pine bark must be composted at least four weeks to destroy their stimulatory effects to *Rhizoctonia.* Fortunately, after such organic matter has decomposed to a point where plant pathogens no longer can utilize it as a food base, beneficial microorganisms still can. Suppression, therefore, can begin at this stage of decomposition.

Composts prepared from wastes differ in the length of time that it takes to reach a point where nitrogen immobilization is not a problem. The length of time that a specific compost remains suppressive also varies. Properties of each type of organic matter, therefore, are reviewed separately below. Considerable quantitative information exists on this subject. However, much of the information available is based on observations with various products in greenhouses and nurseries rather than on controlled studies. The article by Hoitink and Fahy cited below reviews information published before 1985.

Sphagnum Peat

Most of the literature on peats, as it affects plant disease describes its conducive nature. *Both in North America and in Finland batches of sphagnum peat have been identified that suppress Rhizoctonia and Pythium damping-off and also Fusarium wilt of tomato and other crops.* The effect, at least in part, is due to antagonists of these pathogens naturally present in these peat sources. However, the suppressive effect of such peats lasts for up to six to seven weeks only.

In theory, the short term nature of suppressive peats makes them particularly attractive for use in plug mixes or in propagation. Such media would not have to be drenched with fungicides during macropropagation and seedling production, thus avoiding potential phytotoxic responses to fungicides on these juvenile plants. The short-term suppressive effect also may explain why poinsettias can be produced with as few as two sets of fungicide drenches in some batches of Sphagnum peat media, whereas in others, up to four are required.

Fresh Pine Bark

Because of its wood (cellulose) content, pine bark may cause significant nitrogen immobilization. This effect typically lasts six weeks. Therefore, it is not used without composting by the florist industry. In the nursery industry, however, it is utilized most widely.

Fresh pine bark may harbor pathogens. Losses caused by *Rhizoctonia* and *Sclerotium rolfsii* have been observed during propagation of nursery stock in fresh pine bark in Ohio. Heating of fresh pine to temperatures higher than 55° C

(131° F) in windrows kills these pathogens. Turning of windrows is necessary to expose all parts to high temperatures. Losses of this type, however, have not been encountered in rooted cuttings or liners planted in fresh bark media. For most applications, therefore, fresh pine bark can be used with success by the nursery industry.

Composted Pine Bark

Pine bark compost is utilized most widely in container media for the production of floricultural crops today. Up to 50 percent or more (on a volume bases) of the medium may consist of pine bark compost. The physical and chemical properties of pine bark make it ideal for use in container media and have been reviewed before (Hoitink and Faber, 1983). A range of diseases, including those caused by *Rhizoctonia, Pythium, Phytophthora* and now *Fusarium* spp., may be suppressed.

Suppressiveness in pine bark container media varies widely, however. Bark stored in 12-18 ft. high piles for long periods of time reaches high temperatures and undergoes pyrolysis. *Temperatures in bark piles in excess of 80° C (180° F) result in the destruction of cellulose and other components that after composting at much lower temperatures of 40-65° C (100-150° F) form the critical food base for beneficial microorganisms involved in biological control.* Unfortunately, the high temperature-treated (pyrolysed) product also is referred to as a compost or as aged bark in the trade. Some pine bark compost-amended container media, therefore, do not suppress *Rhizoctonia* or *Pythium* damping-off. Such media also do not suppress *Fusarium* wilts.

A biochemical test described below (1) is now available that allows us to distinguish aged bark from compost. This will allow quality control parameters to be developed.

Composted Hardwood Tree Bark

Composts prepared from hardwood tree bark have the most broad spectrum disease suppressive properties. Diseases suppressed are those caused by *Fusarium, Pythium, Phytophthora, Thielaviopsis, Verticillium* and several genera of plant pathogenic nematodes. These advantages of hardwood tree bark composts also bring with them a disadvantage. It continues to decompose throughout crop production. For hardwood bark, this requires additional nitrogen during production of the plant.

Composted hardwood bark still is the best source of bark known to suppress Fusarium wilt diseases. It is used for cyclamen and added by many nurserymen at volumes up to 25 percent in container media to suppress Phytophthora and Pythium root rots of *Ericaceae.*

Composted Municipal Sludge

We often are asked whether fecal pathogens or parasites and the concentrations of heavy metals in sewage sludge composts represent a problem. Federal and state regulations mandate that high temperatures are maintained for specific time periods to ensure pathogen and parasite kill. US-EPA recently completed a nationwide survey which concluded that composted municipal sludges meet these guidelines. Furthermore, Ohio EPA has adopted guidelines for heavy metal concentrations in composted municipal sludges and oversees that municipalities utilize composts accordingly. Composted municipal sludges, therefore, can be utilized safely if all regulations are followed.

Composted municipal sludges have been used in container media by Ohio nurserymen and florists and at Ohio State University since 1981. The following general recommendations now can be made. Just as fecal pathogens are killed during composting of sludges, so are plant pathogens and the beneficial microorganisms that control plant pathogens. The beneficial microflora that is introduced as a contaminant with bark in the sludge composting process is destroyed and must recolonize screened compost during curing. Unless this occurs, media prepared with Sphagnum peat, composted municipal sludge, perlite or styrofoam do not suppress Pythium or Rhizoctonia diseases. The Ohio State Univeristy holds a patent for the controlled addition of specific microorganisms that render media amended with composts consistently suppressive to both types of pathogens. The application of this idea in practice is presently being evaluated.

The amount of composted municipal sludge that should be added to container media varies with the source of the compost but also with the crop. The salinity of municipal sludge composts may range from 4-20 millimhos (saturated paste extract method). Therefore, some composts should be incorporated at volumes not over 5-10 percent. Furthermore, the amount of nitrogen released by sludge composts may be high and is mostly in ammonia form. Future experience undoubtedly will show that the amount of nitrogen mineralized varies with the bulking agent (sawdust, bark or woodchips) used at the composting plant.

We have observed that addition of high volumes of composted municipal sludges (20-25 percent by volume) to container media increases cyclamen Fusarium wilt, Phytophthora diebacks and fire blight. This probably could have been avoided, however, by using lower amounts and by considering the fertility effects (amounts of N, P and K mineralized during crop production) in composted municipal sludge. A volume as low as 2.5 percent added to container media may give a significant growth response.

Increased flower bud set and the "increased growth" observed by E. M. Smith, Jr., W. R. Faber, formerly of Ohio State University, F. R. Gouin from Maryland, and others indeed have been observed in Ohio on selected plants. However, difficulty in slowing down growth of plants that are early for a market also has been encountered as a problem by florists. This negative aspect, however, may be due to the excessive quantity of sludge composts (25 percent or more) used by florists with that experience.

Cow Manure Composts

Data on effects of cow manure composts on plant disease severity or growth in container-produced plants is scant.

Based on research in field plots it is known that cow manures can have a significant effect on soilborne diseases, including Fusarium wilts. Salinity can be a problen. Manures, like sludge composts, tend to be high in soluble salts and vary in quality. Weed seeds also could be present. However, these problems can be overcome by application of existing knowledge of composting and by the adoption of quality control parameters in the preparation of the product for utilization in container media.

Quality Control—Compost-Amended Media

Composts prepared from a consistent source of wastes via a consistent process and finally cured by a consistent process represent products that can be utilized with great benefit. *Only if the complete history of the product is available can media be formulated that yield a predictable response.* Companies involved in the formulation of compost-amended media, therefore, must have direct interests in the composting process.

As described above, significant progress was made at Ohio State University in defining compost quality. *A simple biochemical assay that determines microbial activity in container media and predicts suppressiveness to Pythium root rot has been developed (1). We can now begin to distinguish various types of pine bark products offered for sale today and predict their disease suppressiveness with this method.* Other quality control tests, that assess the degree of decomposition of organic matter are being developed. In the foreseeable future, therefore, guidelines will be available to both producers and growers to check for critical parameters affecting compost quality.

Parameters such as physical properties related to drainage, CEC, pH and total soluble salts are the most useful parameters describing quality of container media today. The history of the product makes the difference between failure and success if composts are added. Much of what makes up product quality still must be considered an art, equivalent to the making of wine, another product of microbiology. The increase in our understanding of the composting and curing processes largely is responsible for the increased opportunities available today for the formulation of media with predictable properties, including disease control. The new procedures referred to above are now being used at Ohio State University to develop guidelines for compost quality. This will remove some of the art, introduce science and eventually force improvements in quality control. The number of times that a given container medium must be drenched with a fungicide to control Pythium diseases will soon be a predictable concept. This concept ultimately will be included in the market price of container media.

References

1. Chen, Weidong, Hoitink, Harry A. J., Scmitthenner, A. Fritz, and Tuovinen, Olli H. 1988. The role of microbial activity in suppression of damping-off caused by Pythium ultimum. Phytopathology 78:314-322.
2. Faber, William R., and Hoitink, Harry A. J. 1983. Critical properties of successful container media. Ohio Florists' Association. Bulletin No. 641. pp 2-6.
3. Hoitink, Harry A. J., and Fahy, Peter C. 1986. Basis for the control of soilborne plant pathogens with composts. Ann. Rev. Phytopathol. 24:93-114.
4. Hoitink, Harry A. J., Daughtrey, Margery, and Tayama, Harry K. 1987. Control of cyclamen Fusarium wilt—a preliminary report. Ohio Florists' Association Bulletin 693. pp. 1-3.U
5. Logan, T. J., Faber, W. R., and Smith, E. M. 1984. Use of composted sludge on different crops. Ohio Report 69 (3):37-40.

TRAVELER GUN IRRIGATION OF FIELD GROWN NURSERY STOCK

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Abstract

The objective of this study was to determine annual irrigation costs for field-grown plants in Ohio by species of plant and size of firm. This objective was accomplished by synthesizing two model field nurseries using an economic engineering approach. Once the nurseries were simulated, growing space was divided into five equal parts with each segment being assigned a plant group. In the 50-acre nursery each group was allocated eight acres of field production plus corresponding space in the propagation house, overwintering facility, holding area, and field bed area. In the 200-acre nursery each plant group was allocated 35 acres plus corresponding space in the central facility. In each plant group, one specific species was chosen as representative for the group.

Total costs of installing irrigation systems were estimated at about $82,500 for a 50-acre field nursery and $167,800 for a 200-acre field nursery. Total annual costs for irrigating the 50-acre nursery were $15,095. Irrigation costs per salable plant (represents the total costs of irrigating the plant from the time it is placed in the field bed as a liner until sale) were $0.73 for slow growing evergreens (*Taxus*), $0.52 for fast growing evergreens (*Juniperus*), $0.49 for deciduous shrubs (*Viburnum*), $1.62 for shade trees (*Acer rubrum*), $1.11 for ornamental trees (*Malus*), and averaged $0.73 for all species. In the 50-acre nursery, costs of irrigation were approximately 3.3 percent of the total costs of production. In the 200-acre nursery total annual costs $0.39 for slow growing evergreens (*Taxus*), $0.28 for fast growing evergreens (*Juniperus*), $0.26 for deciduous shrubs (*Viburnum*), $0.86 for shade trees (*Acer rubrum*), $0.59 for ornamental trees (*Malus*), and averaged $0.39 for all species. Costs of irrigation were about 2.9 percent of total annual costs for the 200-acre nursery.

Costs of irrigation were 87 percent higher per salable plant in the 50-acre nursery than in the 200-acre. Large-size commercial field nurseries use equipment and labor more efficiently than small-sized nurseries. As a result, large nurseries have a lower cost of irrigation per salable plant.

Introduction

The drought of 1988 and to a lesser degree 1987 have caused nurserymen to contemplate either installing new field irrigation systems or expanding current ones. Irrigation is relatively expensive and the cost/benefits are not well known. In fact, cost/benefits are difficult to determine. In a "normal" Ohio year, most field plants grow reasonably well. Research is lacking to determine how much better they would do, in a normal year, if regular waterings were applied. In a drought year, like 1988, non-irrigated plants may suffer severe damage and perhaps death. Surviving plants may never reach their potential.

Even though our knowledge base is incomplete on the effects of irrigation on plant growth and survivability, we can fairly accurately access the cost of using irrigation. This information will be useful to nursery operators in determining whether to invest in irrigation equipment. Therefore, the objectives of this article are to determine irrigation equipment needed for two sized field nurseries, its cost, and the costs per salable plant of providing irrigation.

There are several general irrigation methods for watering field grown nursery plants. Some of them are: traveler gun, set, central pivot, and trickle. This article examines the traveler gun, currently the most popular method of field irrigation of nursery crops.

Traveler gun technology is often grouped into two categories: "cable tow" and "drum type." The drum type is currently the most popular for nursery production and will be examined in detail. First, however, we describe how the cable tow system works.

The cable tow system has been in use in the United States for a longer period than the drum. The machine is self-contained, operates on wheels, and is powered either by water pressure or an internal combustion engine. It is towed across an irrigation surface by a winch and cable. The cable is anchored on one side of the field and the traveler unit moves across the surface, irrigating as it moves. A rubber hose which supplies the water under pressure to the sprinkler gun is dragged behind the traveler unit.

The "drum" is the "traveler" system of preference for the nursery industry. Instead of the entire unit moving across the field (as was the case for the cable tow), normally the drum and pump unit remains stationary and only the sprinkler gun mounted on two wheels or skids is pulled across the field.

Drum units have a polyethylene hose mounted on a drum or reel. Polyethylene hose diameters range from less than 1.5 to over 5 inches and range in length from less than 400 to over 1500 feet. Capacity ranges from less than 30 to over 900 gallons per minute. A large unit can irrigate as many as 35 acres with 1 inch of water in a 20-hour day. They are usually operated by one person who can be employed in other activities the majority of the time. Many of the modern units have fairly sophisticated features: powered by efficient water

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driven turbine, piston, or bellows a "irrigation run," full circle swivels, mechanical gun cart lift for traveling, ability to expel water from the tubing and to reel-in the polyethylene tube without irrigating, adjustable wheel widths for both the main unit and the wheels or sleds on the gun sprinkler, and high clearance carts for clearance.

The main advantages of drum traveler units are high irrigation capacity, easy mobility, rapid installation, and low labor requirements. Their major drawbacks are fairly rapid application of water that can lead to runoff and erosion.

Materials and Methods

In the study, two model firms were simulated using the conceptual framework of economic engineering wherein the "best proven practice" was included in each model. The analysis is based on conditions in central Ohio. The complete model specified involved developing an appropriate production cycle of plants produced, schematic drawings of the physical layout, lists of machinery and equipment and other items, and budgets for fixed and variable costs. Data for this study were obtained in the late summer of 1988 from nursery irrigation suppliers.

A model irrigation system was simulated for both a 50-acre and a 200-acre field nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having its own unique production cycle. Commonly grown nursery stock were divided into five cultural groups. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. The 50-acre nursery had 10 acres and the 200-acre nursery 25 acres of production facilities including overwintering houses, propagation facilities, shipping area, holding area, liner bed area, pond, supply shed, machinery storage, machine shop, office, and rest rooms. The remaining areas were for field production. For analytical purposes, it was assumed that each cultural group would occupy 20 percent of the field growing area (i.e., 50-acre nursery=8 acres per group, 200-acre nursery=35 acres). The irrigation analysis includes field production and the corresponding irrigation requirements for winter storage, holding area, and liner bed area. It does not include budgets for watering in the propagation house. No charge was associated with managing the irrigation equipment.

Capital requirements for establishing the irrigation systems were first determined (Tables 1-4). Second, annual fixed costs were calculated (Tables 5-6). Third,irrigation time requirements were determined (Table 7). Fourth, annual variable costs were determined for each of the two different-sized nurseries (Tables 8 & 9). Fifth, summaries were made for annual fixed and variable costs according to size of nursery (Table 10). Sixth, summaries were made for total costs of irrigation per salable plant based on species of plant and size of nursery.

Total annual irrigation costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation of buildings and equipment, interest charges (both for borrowed and equity capital), insurance, and taxes. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. Variable costs are comprised of all expenses that vary with the amount of irrigation being applied. Variable costs are explicit, obvious, and normally paid out yearly. Variable costs were subdivided into the following categories: repairs, operating, and labor.

Repairs.

Repairs per hour of irrigation system usage were based on percent of new cost over the life of the asset.

Operating.

Operating costs (electricity) were based on an estimate of 8 cents per pump horsepower per hour, $1.10 per gallon of gasoline and 15 percent of the gasoline cost for tractor filters and lubrication.

Labor.

It was estimated that it requires approximately 1½ hours of labor to set up a 5-10 hour irrigation run. While the gun is irrigating, it would require no or a minimum amount of supervision. To take into account supervision, getting to and from the field, etc., labor was budgeted at ¼ the time the gun would be operating. Labor cost was estimated at a basic cost of $5.60. In addition 32 percent was added for taxes and fringe benefits making a total of $7.20 per hour.

Cost Summaries.

After all irrigation cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

Results and Discussion

Total costs of installing the irrigation systems were $82,486 for the 50-acre nursery and $167,833 for the 200-acre nursery (Tables 1 thru 4). Annual fixed, variable, and total irrigation costs for the two-sized field nurseries were $15,097 for the 50-acre ($301.94 per overall acre or $377.43 per field acre) and $35,354 for the 200-acre ($176.77 per overall acre or $202.02 per field acre) (Tables 5 thru 10). In the 50-acre nursery irrigation costs per salable plant were $0.73 per 18-24" slow growing evergreen (*Taxus*), $0.52 per 18-24" fast growing evergreen (*Juniperus*), $0.49 per 3-4' tall deciduous shrub (*Viburnum*), $1.62 per 2" diameter shade tree (*Acer Rubrum*), and $1.11 per 5-6' tall (1 1/2" diameter) ornamental tree (*Malus*). Cost per salable plant produced averaged $0.73 (Table 11). In the 200-acre nursery irrigation costs per salable plant were $0.39 per 18-24" slow growing evergreen (*Taxus*), $0.28 per 18-24" fast growing evergreen (Juniperus), $0.26 per 3-4" tall deciduous shrub (*Viburnum*), $0.86 per 2" diameter shade tree (*Acer Rubrum*), and $0.59 per 5-6" (1 1/2" diameter) ornamental tree (*Malus*). Cost of irrigation per salable plant produced averaged $0.39 (Table 12). It averaged 87 percent more to irrigate a salable plant in the 50-acre nursery than was the case in the 200-acre nursery. Large-size commercial field nurseries use equipment and labor more effectively than small-size nurseries. Costs of expensive equipment can be spread over more acres in large nurseries, thereby providing a lower cost of irrigatin per salable plant.

In 1985, in an earlier study (1), total costs of producing the same combinations of field grown plants averaged $20.34 per salable plant in the 50-acre nursery and $12.43 in the 200-acre. If we assume 10 percent inflation since 1985, the cost would be $22.37 in the 50-acre and $13.67 in the 200-acre. If we compare our average cost of irrigation with total costs of production, cost of irrigation per salable plant was 3.3 percent of total cost for the 50-acre nursery and 2.9 percent for the 200-acre nursery. Individual nurserymen will have to determine whether a 2-4 percent increase in the cost of production for irrigation would be justified for additional plant growth and survival.

Table 1. Cost of irrigation system (Traveler Gun) for a 50 and 200 acre field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

	50 Acre Field Nursery[1]	200 Acre Field Nursery[2]
Item	Total Cost (dollars)	Total Cost (dollars)
Winter Storage and Holding Area[3]		
Inground irrigation system	7,442	19,488
Above ground irrigation system		
Polyhouse structures	1,113	4,267
Holding area	1,562	5,423
Subtotal (Winter storage and holding area)	10,118	29,178
Field/Bed Irrigation[4]		
Inground irrigation system	12,636	38,943
Above ground irrigation system	2,275	5,396
Tractor	3,808	7,615
Traveler gun	15,000	22,000
Subtotal (field irrigation)	33,719	73,954
TOTAL (Not including well, pump, and pond)	40,029	95,517
Cost of well[5]	14,175	15,750
Cost of pump (50-acre=40 HP, 200-acre=100 HP)[4]	16,874	22,701
Cost of the pond	7,600	26,250
Total for irrigation system	82,486	167,833

[1]50 acres total
[2]200 acres total
[3]For details, see Table 3
[4]For details, see Table 2
[5]For details, see Table 4

Table 2. Cost of bed and field irrigation (Traveler Gun) for a 50 and 200 acre field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

Item	Unit	Cost Per Unit (dollars)	50 Acre Field Nursery[1] Quantity Needed	50 Acre Field Nursery[1] Total Cost (dollars)	200 Acre Field Nursery[2] Quantity Needed	200 Acre Field Nursery[2] Total Cost (dollars)
Field/Bed Irrigation						
Inground Irrigation System						
8" pipe, PVC mainline pipe	foot	4.50	450	2,025	4,372	19,674
6" pipe, PVC mainline pipe	foot	2.62	1,659	4,347	1,008	2,641
4" pipe, PVC upright pipe	foot	1.33	32	43	64	85
Hydrant	each	180.00	8	1,440	16	2,880
Additional required equipment, estimated at 25% of pipe & hydrant value				1,964		6,320
Installation charges						
for 6" and 8" pipe	foot	1.35	2,056	2,777	5,380	7,263
for 4" pipe	foot	1.26	32	40	64	80
Subtotal (inground irrigation system)				12,636		38,943
Above Ground Irrigation System						
3" pipe, Aluminum portable latchless	foot	1.98	820	1,624	1,940	3,841
Additional required equipment, estimated at 25% of pipe value				406		960
Sprinkler risers 3/4" x 48"	each	7.00	14	98	34	238
Rotating sprinkler, #30BH Rainbird, nozzle size 5/32" x 3/32"	each	10.50	14	147	34	357
Subtotal (above ground irrigation system)				2,275		5,396
Tractor, 34 hp, gas fuel	each	15,230	1/4	3,808	1/2	7,615
Traveler Gun 70-225 gpm	each	15,000	1	15,000		
Traveler Gun 450-500 gpm	each	22,000			1	22,000
TOTAL BED AND FIELD IRRIGATION				33,719		73,954

[1]50 acres total
[2]200 acres total

Table 3. Cost of irrigation system for the winter storage and holding area for a 50 and 200 Acre field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

			50 Acre Field Nursery[1]		200 Acre Field Nursery[2]	
Item	Unit	Cost Per Unit (dollars)	Quantity Needed	Total Cost (dollars)	Quantity Needed	Total Cost (dollars)
Inground Irrigation System						
8" pipe, PVC	foot	4.50	506	2,277	1,656	7,452
6" pipe, PVC	foot	2.62	640	1,677	1,089	2,853
4" pipe, PVC	foot	1.33	379	504	1,114	1,482
2" pipe, PVC	foot	0.52	36	19	124	65
Additional required equipment, estimated at 20% of pipe value				895		2,370
Installation charges						
for 6" and 8" pipe	foot	1.35	1,146	1,547	2,745	3,706
for 2" and 4" pipe	foot	1.26	415	523	1,238	1,560
Subtotal				7,442		19,488
Above Ground Irrigation System						
1. Polyhouse structures-storage						
1-frost free hydrant 1" @ $60.00						
200 ft of 1" PVC pipe @ $0.24/foot =$48.00						
Installation labor/parts, estimated at 30% of pipe cost=$14.40						
10-rotatinhg sprinklers, Nelson Whizhead 5/64" nozzels @ $5.25 5 $52.20	polyhouse	174.60	5	1,113[3]	21	4,267[3]
2. Holding area						
3" pipe, latchless aluminum	foot	1.85	600	1,110	2,080	3,848
Additional fittings 25% of pipe cost				278		962
Pipe riser 3/4" diameter x 48"	each	7.00	10	70	35	245
Rotating sprinkler, #30BH Rainbird, Nozzle size 5/32" x 3/32"	each	10.50	10	105	35	368
Subtotal (Above ground irrigation system for storage and holding area)				2,676		9,690
Total				10,118		29,178

[1]50 acres total
[2]200 acres total
[3]cost includes extra frost free hydrants used in other areas (4 in the 50-acre nursery and 10 in the 200-acre nursery)

Table 4. Specifications and costs of installing 20, 40, 75, and 100 H.P. electric well pumps and an 80 foot well, U.S.D.A. climatic zones five and six, 1988.

	Horse Power[1]			
Specifications (dollars)	20	40	75	100
	.... dollars			
Pump—above ground, lineshaft, 1,800 RPM				
Basic electric motor, 3 phase, 220 volt	1,680	2,310	3,675	4,291
Discharge head—6" x 1" collar	998	998		
8" x 1" collar			1,256	1,256
Standard 10' length, inner column, 80' depth	2,100	2,205	3,990	4,541
Pipe and suction pipe	357	357	357	357
Pump bowl assembly—9 stage, 8" pump	2,520			
4 stage, 10" pump		2,310		
3 stage, 12" pump			2,822	2,822
Air line gauge	47	47	47	47
Well seal, well plate, cement	368	368	368	368
Electrical equipment	92	92	92	92
Installation fee	1,050	1,050	1,050	1,050
Right angle gear drive, auxillary power source[2] using a tractor	1,470	1,785	1,995	1,995
Subtotal	10,682	11,522	15,652	16,819
+Freight @ 10%	1,068	1,152	1,565	1,682
+Building	4,200	4,200	4,200	4,200
Total cost for pump, including shelter	15,950	16,874	21,417	22,701
Well Drilling				
Casting diameter, 12	12,600			
14" O.D.		14,175		
16" O.D.			15,750	15,750
Total cost for well	12,600	14,175	15,750	15,750
TOTAL	28,550	31,049	37,167	38,451

[1]A 20 H.P. pump can supply 300 gallons of water per minute at 55 psi given the specifications and site location. A 40 H.P. pump can supply 500 gallons of water per minute at 55 psi given the specifications and site location. A 75 or 100 H.P. pump can supply 900 gallons of water per minute at 65 psi given the specifications and site location.

[2]The right angle drive would operate with the largest nursery tractor (60-100 HP). It would be used for pumping water from the well to the pond, and in a separate operation from the pond into the irrigation system.

Table 5.—Annual fixed costs (dollars) for a Traveler Gun Irrigation System for a 50 acre[1] field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

				Annual Costs			
Item	Description	Cost	Useful Life (Yrs)	Depreciation[2]	Interest[3]	Insurance and Taxes[4]	Total
Land Improvements	Pond	7,600	20	—	456	152	608
Machinery and Equipment							
Permanent irrigation/well pump	40 HP electric pump	31,049	20	1,397	2,049	117	3,563
Inground irrigation/bed area	PVC pipe/valves	12,636	20	569	834	48	1,451
Above ground irrigation/bed area	Aluminum pipe/valves and sprinklerheads	2,275	5	410	150	9	569
Inground irrigation storage/holding	PVC pipe/valves	7,442	20	335	491	28	854
Above ground irr. storage/holding	Aluminum pipe/valves and sprinklerheads	2,676	5	482	177	10	669
Tractor, 34 hp (1/4 of a unit)	Gas fuel	3,808	10	343	251	14	608
Traveler gun—field irrigation	70-225 gallons per minute	15,000	10	1,350	990	57	2,397
Portable irrigation pump	40 HP P.T.O. irrigation pump/foot value	500	10	45	33	2	80
Total Annual Fixed Costs				4,931	5,431	437	10,799

[1]Fifty acre total, 40 acres growing space, 10 acres production facilities, holding area, field bed area, roads, etc.
[2]Depreciation was estimated by dividing initial cost adjusted for a 10% salvage value, by the years of useful life.
[3]Interest costs for land improvements was estimated by taking 12% of the average value based on initial value. Initial cost on machinery and equipment was estimated by taking 12% of the average value based on initial cost and salvage value. It was calculated as (((initial value plus salvage value)/2)x.12).
[4]Insurance and taxes.
Land improvements—Only taxes are assessed, at a rate of $20.00 per $1000.00 of market value.
Machinery and equipment—Taxes are not assessed in state of Ohio on personal property. Insurance, $500.00 deductible, at$3.78 per $1000.00 of initial value.

Table 6. Annual fixed costs (dollars) for a Traveler Gun Irrigation System for a 200 acre[1] field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

Item	Description	Cost	Useful Life (Yrs)	Annual Costs: Depreciation[2]	Interest[3]	Insurance and Taxes[4]	Total
Land Improvements	Pond	26,250	20	—	1,575	525	2,100
Machinery and Equipment							
Permanent irrigation/well pump	100 HP electric pump	48,951	20	2,203	3,231	185	5,619
Inground irrigation/bed area	PVC pipe/valves	38,943	20	1,752	2,570	147	4,469
Above ground irrigation/bed area	Aluminum pipe/valves and sprinklerheads	5,396	5	971	356	20	1,347
Inground irrigation storage/holding	PVC pipe/valves	19,488	20	877	1,286	74	2,237
Above ground irr. storage/holding	Aluminum pipe/valves and sprinklerheads	9,690	5	1,744	640	37	2,421
Tractor, 34 hp (1/2 of a unit)	Gas fuel	7,615	10	685	502	29	1,216
Traveler gun—field irrigation	450-500 gallons per minute	22,000	10	1,980	1,452	83	3,515
Portable irrigation pump	40 HP P.T.O. irrigation pump/foot valve	500	10	45	33	2	80
Total Annual Fixed Costs				10,257	11,645	1,102	23,004

[1]two hundred acre total. 175 acres growing space. 25 acres production facilities, holding area, field bed area, roads, etc.

[2]Depreciation was estimated by dividing initial cost adjusted for a 10% salvage value, by the years of useful life.

[3]Interest costs for land improvements was estimated by taking 12% of the average value based on initial value. Interest cost on machinery and equipment was estimated by taking 12% of the average value based on initial cost and salvage value. It was calculated as (((initial value plus salvage value)/2) x .12).

[4]Insurance and taxes.

Land improvements—Only taxes are assessed, at a rate of $20.00 per $1000.00 of market value.

Machinery and equipment—Taxes are not assessed in state of Ohio on personal property. Insurance, $500.00 deductible, at $3.78 per $1000.00 of initial value.

Table 7. Time requirements[1] for field irrigation (Traveler Gun) for a 50 and 200 acre field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

Type of Crop	50 Acre Field Nursery[2]				200 Acre Field Nursery[3]			
	Hours/ acre	Irrigated Acres	Man Hours	Pump Hours	Hours/ acre	Irrigated Acres	Man Hours	Pump Hours
	.... per irrigation							
Slow growing Evergreens (Taxus)	2.0	6.9	3.5	13.8	1.0	30	7.5	30
Fast growing Evergreens (Junipers)	2.0	6.4	3.2	12.8	1.0	28	7.0	28
Deciduous Shrubs (Viburnum)	2.0	6.0	3.0	12.0	1.0	27	6.8	27
Shade Trees (Acer rubrum)	2.0	6.4	3.2	12.8	1.0	28	7.0	28
Ornamental Trees (Malus)	2.0	6.0	3.0	12.0	1.0	27	6.8	27
Total per irrigation		31.5	15.9	63.4		170	35.1	140
x6 irrigations/year		189	95.4	380		1,020	210	840

[1]Assumptions.

1. In a average year, a nursery would apply approximately 6 to 7 acre inches of water. The systems have the capacity to apply 12-15 acre inches in a dry season.
2. Irrigate every year except cover crop year.
3. If fields are properly arranged, it will take approximately 10 hours per pull. It requires about 1½ hrs of labor to set up a pull. We estimated labor at¼ the pump hours to take into account getting to and from the field and handling the set up.

[2]50 acres total. The 50-acre nursery would use a traveler gun with a maximum capacity of 225 gallons per minute.

[3]200 acres total. The 100-acre nursery would use a traveler gun with a maximum capacity of 483 gallons per minute.

Table 8. Estimated variable cost for field irrigation (Traveler Gun) for a 50-acre field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

Item Number	Item	New Cost (dollars)	Expected Life (years)	Estimated Annual Use (hours)	Estimated Cost per Hour of Use: Repairs[1] (dollars)	Estimated Cost per Hour of Use: Operating[2]	Estimated Cost per Hour of Use: Total (dollars)	Total Variable Costs (dollars)
1	Permanent irrigation,well+pump	24,474	20	425[3]	0.29	3.20	3.49	4,483
2	Inground irr, bed-field	12,636	20	380	0.67		0.67	255
3	Above ground irr. bed-field	2,275	5	380	0.48		0.48	182
4	Inground irr, storage/holding (S.&H.)	7,442	20	60	2.48		2.48	149
5	Above ground irr. S.&H.	2,676	5	60	3.57		3.57	214
6	Traveler	15,000	10	380	1.58		1.58	600
7	Portable irr. pump (emergency)	500	10	—	—	—	—	
8	Tractor, 34 hp (1/4 of a unit)	3,808	10	106	3.23	2.92	6.15	652
	Labor[4]			106			7.20	763
Total								4,298

[1]Repairs per hour were based on percent of new cost over the life of the asset. Percent factors used were: 10 for item number 1, 40 for numbers 2 thru 7, and 90 for item 8. The total was then divided by the estimated total number of hours the equipment would be used over its total life (i.e., the well & pump would be used 8,500 hours over a 20 year period).

[2]Operating cost was estimated at 8 cents per pump horsepower per hour. A 40 horsepower pump would therefore cost $3.20 per hour for electricity and lubrication, gasoline for the tractor was estimated at $1.10 per gallon, and 15% of the cost of gasoline was allocated for lubrication and filters.

[3]It was estimated that¼ (15 hours) of the time the storage and holding area is being irrigated it would occur concurrently with field irrigation. The other¾ (45 hours) of the time, the pump would need to be run for the storage and holding area only.

[4]Labor was estimated at¼ the pump hours. Average basic wage before withholding taxes and fringes $5.60, taxes and fringes add 32% or $1.80 for a total of $7.20.

Table 9. Estimated variable cost for field irrigation (Traveler Gun) for a 200-acre field nursery, U.S.D.A. plant hardiness zones five and six, 1988.

					Estimated Cost per Hour of Use			
Item Number	Item	New Cost (dollars)	Expected Life (years)	Estimated Annual Use (hours)	Repairs[1] (dollars)	Operating[2]	Total (dollars)	Total Variable Costs (dollars)
1	Permanent irrigation,well+pump	48,951	20	870[3]	0.28	8.00	8.28	7,204
2	Inground irr. bed-field	38,943	20	840	0.93		0.93	781
3	Above ground irr. bed-field	5,396	5	840	0.51		0.51	428
4	Inground irr. storage/holding (S.&H.)	19,488	20	60	6.49		6.49	389
5	Above ground irr. S.&H.	9,690	5	60	12.92		12.92	775
6	Traveler	22,000	10	840	1.05		1.05	882
7	Portable irr. pump (emergency)	500	10	—	—	—	—	
8	Tractor, 34 hp (1/2 of a unit)	7,615	10	218	3.14	2.92	6.06	1,321
	Labor[4]			218			7.20	1,570
TOTAL								12,350

[1]Repairs per hour were based on percent of new cost over the life of the asset. Percent factors used were: 10 for item number 1, 40 for numbers 2 thru 7, and 90 for item 8. The total was then divided by the estimated total number of hours the equipment would be used over its total life (i.e., the well & pump would be used 17,400 hours over a 20-year period).

[2]Operating cost was estimated at 8 cents per pump horsepower per hour. A 100 horsepower pump would therefore cost $8.00 per hour for electricity and lubrication, gasoline for the tractor was estimated at $1.10 per gallon, and 15% of the cost of gasoline was allocated for lubrication and filters.

[3]It was estimated that¼ (15 hours) of the time the storage and holding area is being irrigated it would occur concurrently with field irrigation. The other¾ (45 hours) of the time, the pump would need to be run for the storage and holding area only.

[4]Labor was estimated at¼ the pump hours. Average basic wage before withholding taxes and fringes $5.60, taxes and fringes add 32% or $1.80 for a total of $7.20.

Table 10. **Summary of fixed and variable costs (dollars) for irrigation for a 50 acre[1] and 200 acre[2] field nursery, U.S.D.A. plant hardiness zones five and six, 1985.**

	50 Acre Field Nursery[1]			200 Acre Field Nursery[2]		
	Total for Nursery	Per Overall Acre	Per Field Acre[3]	Total for Nursery	Per Overall Acre	Per Field Acre[3]
Fixed Costs	10,799	215.98	269.98	23,004	115.02	131.45
Variable Costs	4,298	85.96	107.45	12,350	61.75	70.57
TOTAL	15,097	301.94	377.43	35,354	176.77	202.02

[1]50 acres total with 40 acres of field growing space, and 10 acres of production facilities, holding area, field bed area, roads etc .

[2]200 acres total with 175 acres of field growing space, and 25 acres of production facilities, holding area, field bed area, roads etc.

[3]Includes prorated share of costs for irrigation in the overwintering and holding areas.

Table 11. **Summary of total costs per salable plant of irrigating (Traveler Gun) 50 and 200-acre field nurseries, U.S.D.A. plant hardiness zones five and six, 1988.**

			50 Acre Field Nursery[1]			200 Acre Field Nursery[1]		
Item	Description	Size of Salable Plant	Salable Plants Produced per annum	Total Annual Cost for Irrigation (dollars)	Cost per[3] Salable Plant (dollars)	Salable Plants Produced per annum	Total Annual Cost for Irrigation (dollars)	Cost per[3] Salable Plant (dollars)
I	Slow Growing Evergreens-Taxus	18-24"	4,140	3,019	0.73	18,156	7,071	0.39
II	Fast Growing Evergreens-Juniperus	18-24"	5,810	3,019	0.52	25,418	7,071	0.28
III	Deciduous Shrubs-Viburnum	3-4'	6,208	3,019	0.49	27,162	7,071	0.26
IV	Shade Tree-Acer rubrum	2"diameter	1,869	3,019	1.62	8,177	7,071	0.86
V	Ornamental Tree-Malus	5-6' (1 1/2")	2,732	3,019	1.11	11,954	7,071	0.59
TOTAL			20,759	15,095	0.73	90,867	35,355	0.39

[1]50 acres total with 40 acres of field growing space, and 10 acres of production facilities, holding area, field bed area, roads, etc. Each plant category was assigned 20% of the field production area or 8 acres.
[2]200 acres total with 175 acres of field growing space, and 25 acres of production facilities, holding area, field bed area, roads, etc. Each plant category was assigned 20% of the field production area or 35 acres.
[3]this represents the total cost for irrigation of the salable plant. In the small nursery, for example, the 8 acres used for producing Slow Growing Evergreens contains a seven-year rotation. Only 1/7 of the area is harvested each year. In addition to field production, Taxus plants spend three years in the propagation house, and three years in liner beds.

POTENTIAL OF SLOW-RELEASE TABLETS AS CARRIERS OF HERBICIDES AND GROWTH REGULATORS FOR CONTAINERIZED ORNAMENTALS.

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Abstract

Experimental slow-release tablets were prepared with herbicides and growth regulators, and their potential for practical application on containerized ornamentals was examined. The area of weed control around tablets loaded with herbicide was markedly increased by adding a surfactant to the tablet. This effect is of particular importance for herbicides having a low water solubility, such as isoxaben, oryzalin, oxadiazon and oxyfluorfen. Tablets with various growth regulators used in horticulture were applied to herbaceous and woody plants. Strong growth retardation was achieved by tablets containing Sumagic, and to a lesser degree with Bonzi (paclobutrazole).

Introduction

The concept of tablets with slow-release chemicals is of particular interest for producers of container-grown ornamentals. Tablets are easy to handle and direct placement on container surface avoids the spillage caused by spray or granules spreading over-the-top of the plants, in which an appreciable portion of the applied chemical falls on the soil between the containers. Ideally, slow-release herbicide tablets should provide long-lasting weed control in the container. Tablets made of plaster-of-paris, and subsequently, of calcium phosphate, gave good weed control with water-soluble herbicides, such as alachlor, metolachlor or metribuzin, but not with herbicides having a low-water solubility (4, 5, 7, 8, 9, 10, 12, 13).

However, most preemergence herbicides currently recommended for ornamentals, because of their control efficiency and crop tolerance, have a very low water solubility; for example: oryzalin (Surflan)—2.4 ppm, oxadiazon (Ronstar)—0.7 ppm, oxyfluorfen (Goal)—0.1 ppm, in comparison to metolachlor (Dual), whose water solubility is 530 ppm.

Two new approaches are being presently explored to use tablets as carriers for controlled release of chemicals in container-culture:

a) addition of surfactants to tablets loaded with low-water soluble herbicides, in order to enhance their release; and

b) loading tablets with growth regulators.

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Materials and Methods

Tablets were produced by dry compression of a mixture containing dicalcium phosphate as filler, magnesium stearate as binder and the active ingredients in technical or commercial formulation, following the technique developed in The Ohio State University Department of Horticulture (4, 7, 9).

Tablets measured 12 mm in diameter; their width (2-4 mm) and weight (1.0-1.5 g/tablet) depended on the composition of the mixture and the compression applied.

A series of experimental tablets were prepared, containing 1 to 5 percent of formulated or technical herbicide [including isoxaben (Gallery), oryzalin (Surflan), oxadiazon (Ronstar) and oxyfluorfen (Goal)], with or without surfactant. For the study on growth substances, tablets contained 1 or 5 percent of the following formulated growth regulators: A-Rest (0.0264 percent ancymidol), Atrinal (18.5 percent dikegulac), B-Nine (85 percent daminozide), Bonzi (0.4 percent paclobutrazole) and Sumagic (10 percent uniconizole). Experiments were carried out in pots filled with two growth media (Metro Mix 350 and a 6 pine bark:3 peat moss:1 sand by volume mixture) in the greenhouse, under intermittent mist, or outdoors, with sprinkler irrigation. Plants were maintained as for commercial practice.

Results and Discussion

Tablets with herbicides

Our basic assumption is that surfactants, which are known to enhance the solubilization of herbicides in water, and their movement in soil (1, 2, 3), could also improve the release from tablets. To test this hypothesis, tablets with various herbicide and surfactant combinations, were placed on the growing medium surface and oversown with seeds of a bioassay plant, sensitive to tested herbicides. At emergence, a clearcut area of growth inhibition, approximately circular, appeared around the tablet, delineating the zone of herbicide release. Tablets loaded with isoxaben, oryzalin, oxadiazon or oxyfluorfen, plus 1 percent surfactant X-77 or Triton X-100 produced areas of inhibition significantly larger than herbicide alone. An example, comparing tablets of 1 percent and 5 percent Goal (G1, G5) to 1 percent Goal+1 percent X-77 (G1X1) is shown in Table 1. The diameter of the area of activity G1X1 tablets was three times greater than that of G1, and almost twice of G5. In this experiment, the bioassay plant (bentgrass) was sown immediately or five days after placing the tablet; it appeared that the difference between timing was not significant, indicating that the initial release of herbicide and its movement in the growing medium were very rapid. Similar results were obtained with other herbicides; the practical significance is that weed control can be expected immediately after placing the tablet on soil surface.

Table 1. Weed-free area around tablets of Goal (oxyfluorfen), assessed by bentgrass, sown immediately or after 5 days[1]

		Diameter of weed-free diameter (cm)	
	Oxyfluorfen	Bentgrass sown days after tablet	
Tablet[2]	mg/tablet	0	5
G1	2.4	3.7[3]	4.0
G1X1	2.4	12.2	11.6
G5	10.8	6.9	7.7

[1]Single tablets were placed on surface of pots filled with Metro Mix 350, and oversown with bentgrass seeds immediately or after 5 days. Experiment conducted in the greenhouse.
[2]G1, G5=1% or 5% Goal; G1X1=1% Goal+1% X-77.
[3]LSD (5%):0.9.

Experiments on placement showed that tablets put on the growing medium surface produced larger areas of inhibition than when buried, due to the symmetrical release of herbicide around the tablet. It was observed that tablets placed on the surface of pots kept in the open, maintained their form and shape after three months of outdoor exposure. This is significant because surface placement is an easier and less expensive method of application than inserting into the media.

Among the various combinations of herbicides and surfactants tested, the largest area of activity was achieved by 1 percent Goal+1 percent Triton X-100 tablets. The diameter of the weed-free area around a single tablet was 12 cm in the greenhouse and 15 cm outdoors. This area is sufficient to cover small pots. In larger pots, several tablets will be required. It has been observed that plants transplanted with a large root ball may interfere with the regular flow of herbicide around the tablet. Further research is necessary to determine the optimal geometry of tablet placement.

Summarizing a series of experiments with different tablets and conditions, two conclusions are of practical interest:

a) in spite of marked differences in air and soil moisture between the greenhouse (mist) and outdoor (sprinkler or rain), the areas of activity reported for a given tablet were similar, or even slightly larger, in the open than inside; and
b) between the two growth media tested, only insignificant differences were recorded.

Thus, at this stage of the work, the scope of possible use of these herbicide tablets appears to be most promising.

Several problems have not yet been sufficiently studied, and must be clarified before introducing the tablets into commercial practice:

1) persistence of the herbicidal activity from slow-release tablets over time, as compared to conventional application;
2) tolerance of ornamental species to herbicide rates delivered by these tablets;
3) optimization of tablet placement according to plant and container size; and
4) systematical screening for possibly more active herbicide-surfactant combinations.

Tablets with growth regulators

Growth regulators are applied on container-grown ornamentals by overall spray or soil drench, and often several applications are required (11). Granules loaded with growth regulators have also been tested (6, 14). These methods of application lack precision and cause losses of chemical. With the development of new growth-regulators, such as paclobutrazol (Bonzi) or uniconizole (Sumagic), much greater precision in metering and timing is becoming indispensable. Ideally, a slow-release carrier can provide the plant with the active ingredient required for a prolonged period. Tablets, containing the appropriate rate of chemical for a given plant and conditions, are simple to apply and avoid waste. However, they are suitable only for substances which are absorbed by plant roots.

Exploratory tests were carried out on herbaceous flowering plants potted in Metro Mix 350 and kept under intermittent mist in the greenhouse. A single tablet was placed on the soil surface close to the plant stem. After testing chrysanthemum, geranium, zinnia and impatiens, it was found that the latter gave the fastest and clearest response (Table 2). There was practically no effect from A-Rest and B-Nine tablets, a slight effect from Bonzi 5 percent and a marked effect from Sumagic. Retardation in growth of Sumagic-treated plants became apparent after one week. Two months after application, the growth effect was still very clear, indicating that the release of active substance is rapid at the initial stage and continuous. Another series of experiments was made on woody shrubs, grown in a 6 pine bark:3 peat moss:1 sand mixture and kept outdoors, under sprinkler irrigation. The tablets were placed on the soil surface close to the plant stem. Results with Royal Beauty Cotoneaster are presented in Table 3; similar effects were recorded on other cultivars of cotoneaster, azalea, euonymus and spirea. The weight of the foliage removed after six weeks, and to a lesser extent the whole weight assessed after 11 weeks, indicate no effect from A-Rest, Atrinal and B-Nine, a limited effect from Bonzi, and a marked growth reduction from Sumagic, particularly at 5 percent. Sumagic-treated plants were more compact and darker green than the control plants.

The main conclusion of the experiments is that tablets loaded with growth regulators are a feasible alternative to spray or drench application, for substances such as Sumagic and Bonzi. The difference in activity between the two compounds may be due to the amount of active substance in the tablet: 1 percent tablets of Sumagic contained 1.3 mg uniconizole, and of Bonzi, only 0.05 mg paclobutrazole, according to the formulated material of which the tablets were prepared. Further research should deal with rates and timing for optimal effect, on various ornamentals. The lack of activity of A-Rest, Atrinal and B-Nine may have been caused by insufficient uptake capacity of the plant roots for these compounds, which would limit the possible use of tablets for these compounds.

Table 2. Effect of growth-regulator tablets on impatiens seedlings.[1]

Tablet Content	Effects on growth, in % of control,[2] weeks after application: Height 3	Height 8	Diameter 3	Diameter 8
A-Rest 1%	100a[3]	93a	100a	96a
B-Nine 1%	117a	109a	101a	94a
Bonzi 1%	108a	100a	98a	98a
Bonzi 5%	89a	88a	85a	95a
Sumagic 5%	41b	49b	20b	42b

[1]Application: 1 tablet per plant, on seedlings of Red Super Elfin impatiens approx. 5 cm, 6-8 pairs of leaves; in the greenhouse, under intermittent mist.
[2]Control (100 %): height—7 and 9 cm after 3 and 8 weeks; diameter—23 and 27 cm after 3 and 8 weeks, respectively.
[3]Figures of a column followed by different letters are significantly different at 5% level, by Duncan's multiple range test.

Table 3. Effect of growth-regulator tablets on cotoneaster plants.[1]

Tablet content	Shoot weight,[2] in % of control[3]: pruning a. 6 weeks	whole a. 11 weeks	Longest branch (cm) a. 11 weeks
A-Rest 1%	95a[4]	96ab	26a
Atrinal 1%	80ab	104a	29a
B-Nine 1%	92a	100ab	27a
Bonzi 1%	79ab	101ab	26a
Bonzi 5%	62b	86b	26a
Sumagic 1%	67b	84b	27a
Sumagic 5%	32c	62c	18b
Control	100a	100a	27a

[1]Application: 1 tablet per plant, on established cuttings of *Cotoneaster dammeri* 'Royal Beauty' approximately 15 cm; pots filled with bark:peat:sand mixture were placed outdoors under sprinkler irrigation.
[2]Shoots pruned 6 weeks after application to 15 cm and all cut foliage weighed (F.W.). After 11 weeks, the whole shoot was cut at soil surface and weighed (F.W.).
[3]Control (100%): weight of pruning—19 g, whole weight—54 g.
[4]Figures of a column followed by different letters are significantly different at 5% level by Duncan's multiple range test.

Figure 1. Area of weed control produced around tablets of oxyfluorfen, assessed by bentgrass. From left to right: Goal 1% + Triton X-100 1%, Goal 1%, Goal 1% + X-77.

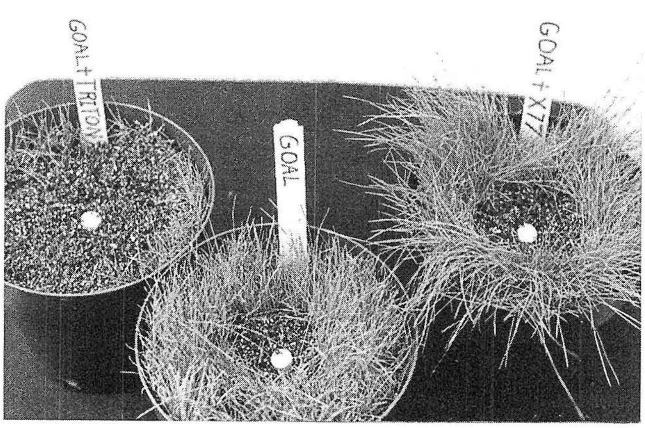

Figure 2. Effect of a tablet containing 5% Sumagic on small impatiens seedling; photograph taken after one month. Left, Sumagic; right, control.

Literature Cited

1. Bayer, D.E. 1967. Effects of surfactants on leaching of substituted urea herbicides in soil. Weeds 15:249-252.
2. Bayer, D.E. and H.R. Drever. 1965. The effects of surfactants on the efficiency of foliar-applied diuron. Weeds 13:222-226.
3. Hill Jr., G.D., I.J. Belasco and H.L. Ploeg. 1965. Influence of surfactants on the activity of diuron, linuron and bromacil as foliar sprays on weeds. Weeds 13:103-106.
4. Koncal, J.J., S.F. Gorske, and T.A. Fretz. 1981. Slow release herbicide formulation for weed control in container-grown plants. Hort Science 16:83-84.
5. Koncal, J.J., S.F. Gorske, and T.A. Fretz. 1981. Leaching of EPTC, alachlor and metolachlor through a nursery medium as influenced by herbicide formulation. Hort Science 16:757-758.
6. Murray, G.E., K.C. Sanderson and J.C. Williams. 1986. Application methods and rates of ancymidol on plant height and seed germination of bedding plants. Hort Science. 21:120-122.
7. Ruizzo, M.A., E.M. Smith and S.F. Gorske. 1983. Evaluations of herbicides in slow-release formulations for container grown landscape crops. J. Amer. Soc. Hort. Sci. 108:551-553.
8. Smith, A.E. and B.P. Verma. 1977. Weed control in nursery stock by controlled release of alachlor. Weed Sci. 25:175-178.
9. Smith, E.M., S.F. Gorski and M. Moore. 1986. An evaluation of metribuzin slow-release tablets on woody landscape crops. Ornamental Plants—1986: A Summary of Research. OARDC Res. Circ. 289:14-17.
10. Smith, E.M. and S.A. Treaster. 1987. An evaluation of cyanazide, terbacil and metolachlor slow release herbicide tablets on woody landscape crops. Ornamental Plants—1987: A Summary of Research. OARDC Res. Circ. 291:15-16.
11. Tayama, H.K. 1987. Insect and mite control, disease control and growth regulator booklet. Ohio Florists' Association Bull. 687, 40 pp.
12. Verma, B.P. and A.E. Smith. 1978. Slow release herbicide tablets for container nursery. Transactions of Amer. Soc. Agr. Eng., 21:1054-1059.
13. Verma, B.P. and A.E. Smith. 1981. Dry pressed slow release herbicide tablets. Transactions of Amer. Soc. Agr. Eng., 24:1400-1407.
14. Wilfret, G.J., B.K. Harbaugh and T.A. Nell. 1978. Height control of pixie poinsettia with a granular formulation of ancymidol. Hort Science. 13:701-703.

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